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JOURNAL

(February, 1946, Vol. XXV, No. 2, Ed. B)

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"ATOMIC ENERGY" *by H. A. PEARSON, B.A. Oxon.*

MEMORANDUM ON "TECHNICAL EDUCATION"
Prepared by The Education Committee of The Institution of Production Engineers

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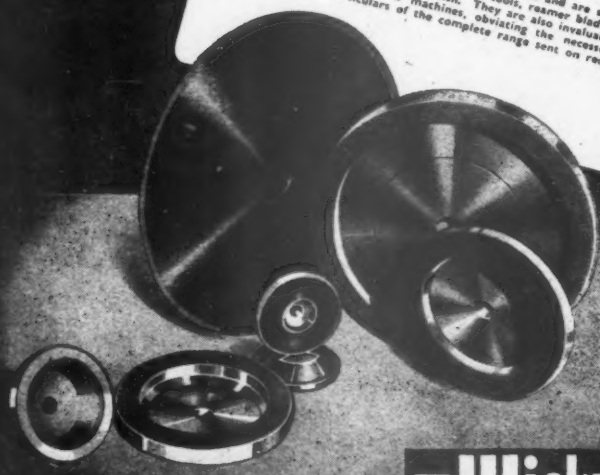

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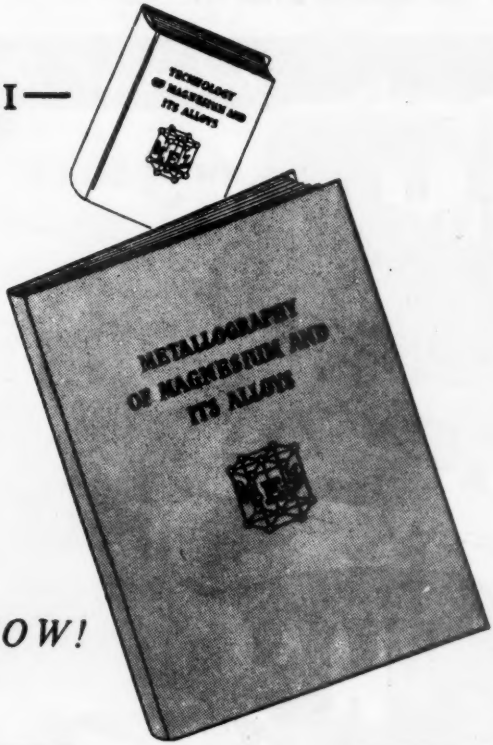

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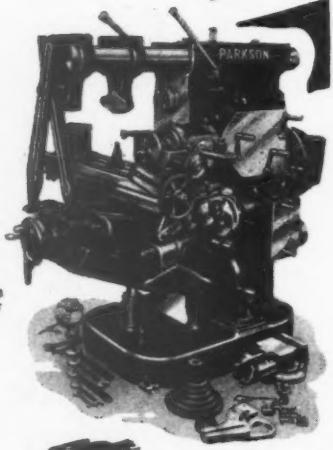

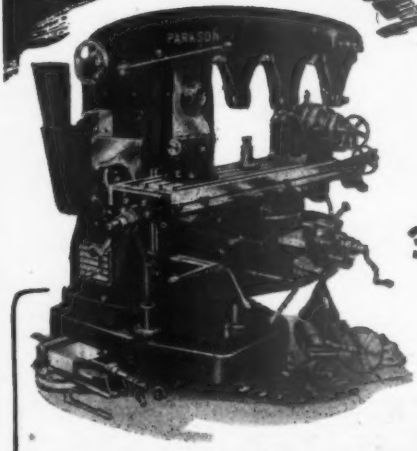

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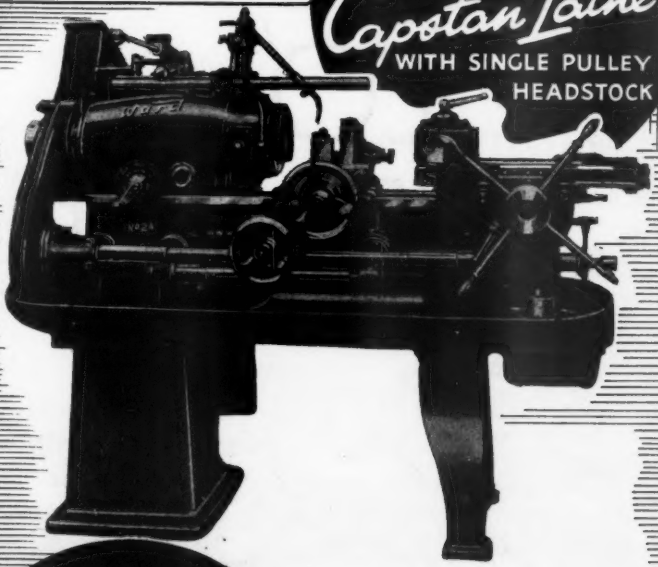

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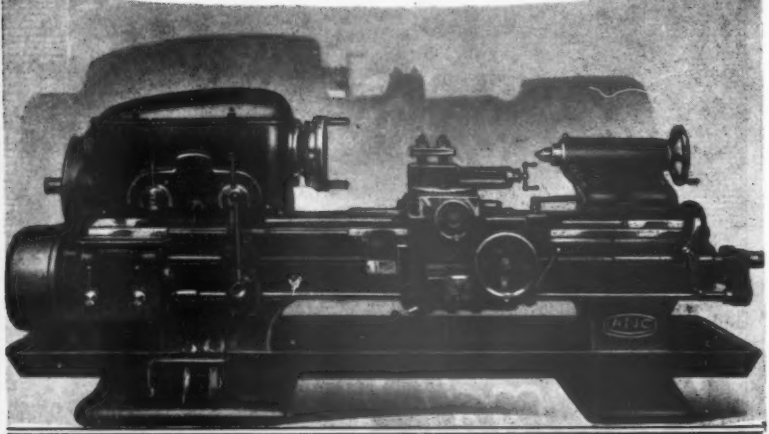

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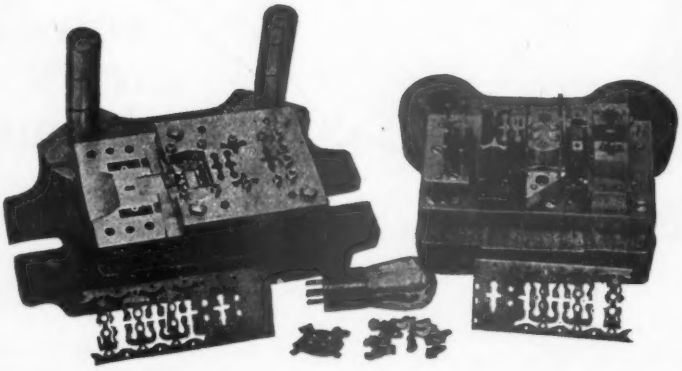

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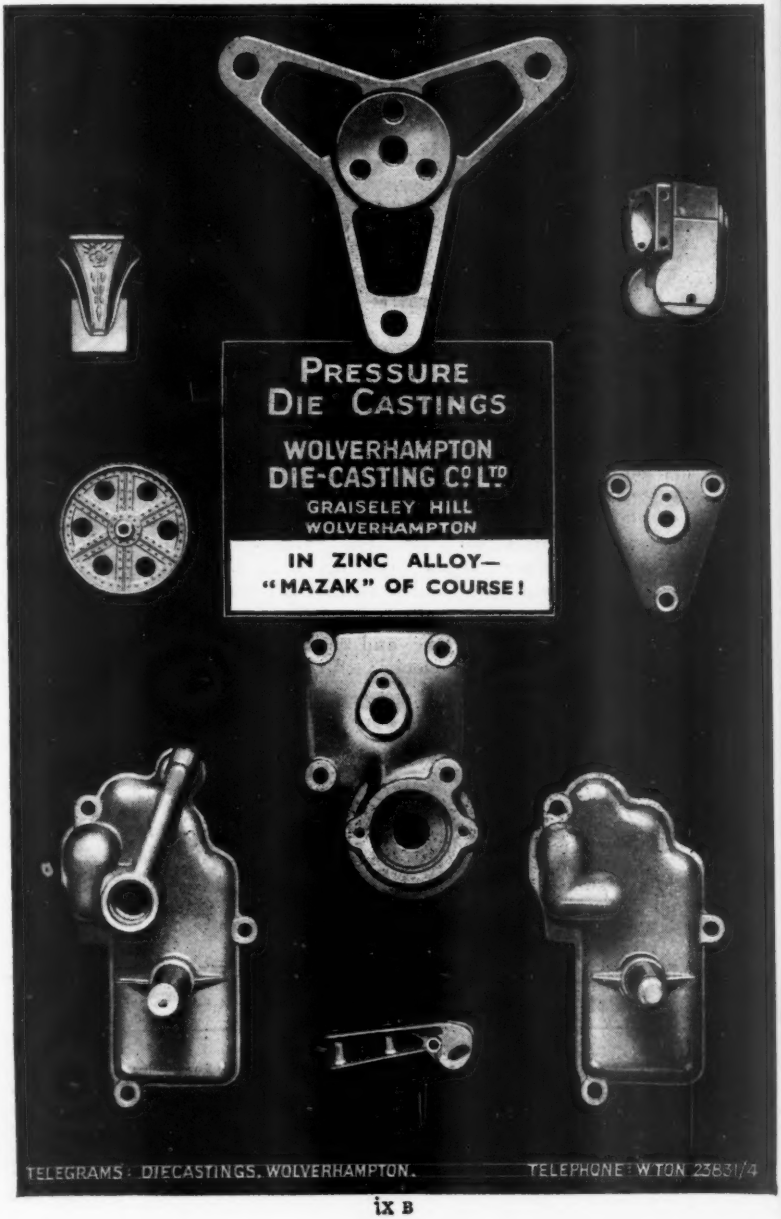
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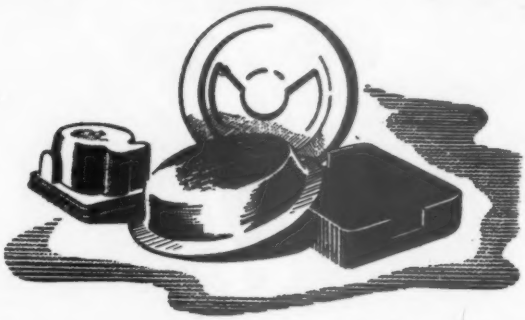

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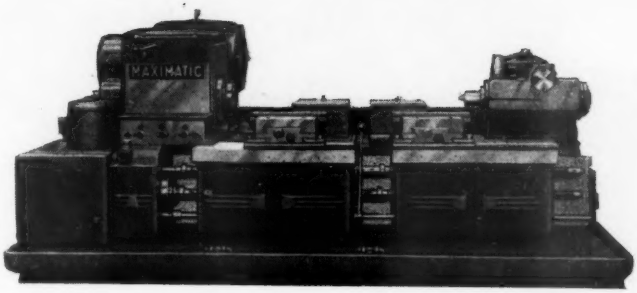

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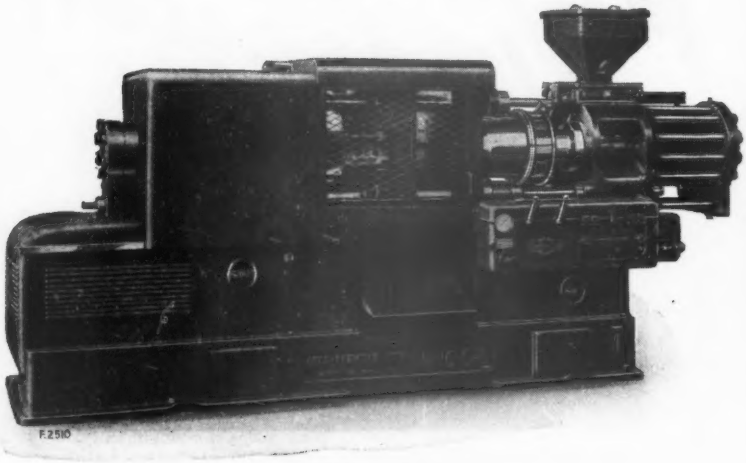

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INSTITUTION NOTES

February, 1946

February Meetings

4th Yorkshire Section. A lecture will be given by A. F. Brockington, Esq., on "Surface Treatment by Electrolysis and Anti-Corrosion Finishes," at the Hotel Metropole, Leeds, at 7-00 p.m.

4th Coventry Graduate Section. A lecture will be given by T. C. Parker, Esq., on "Cold Up-Setting and Thread Rolling," at the Technical College, Coventry, Room A5, at 6-45 p.m.

7th Leicester Section. A lecture will be given by T. C. Parker, Esq., on "Developments of Cold Heading and Thread Rolling," at the Leicester College of Technology, at 7-00 p.m. This lecture will be illustrated by lantern slides.

9th Birmingham Section. A dance will be held at the Grand Hotel, Colmore Row; 6-00 to 11-45 p.m.

9th Manchester Graduate Section. Works visit to Ferguson Pailin, Ltd., Higher Openshaw, Manchester.

12th Luton and District Section. A lecture will be given by T. C. Parker, Esq., on "Cold Forging and Thread Rolling of Bolts and Screws," at The Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

13th Preston Section. A lecture will be given by A. R. Palmer, Esq., on "Gravity Diecasting of Aluminium Alloys," at the Harris Institute, Corporation Street, Preston, at 7-15 p.m.

13th Birmingham Graduate Section. Visit to Messrs. Birmingham Aluminium Castings (1903) Ltd., Dartmouth Road, Smethwick, at 2-15 p.m.

14th South Wales and Monmouthshire Section. A lecture will be given by F. Baker, M.I.P.E., on "Principles of Interchangeable Manufacture," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

14th London Section. A lecture will be given by R. H. Streete, Esq., on "High Frequency Heating," in the Lecture Hall, Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, at 6-30 p.m.

February Meetings—*Cont.*

14th Wolverhampton Graduate Section. Visit to Messrs. F. H. Lloyd & Co., Ltd., James Bridge Steel Works, nr. Wednesbury, at 2-00 p.m.

15th Western Section. A lecture will be given by W. Whitworth Taylor, Esq., on "Milling," at the Grand Hotel, Broad Street, Bristol, 1, at 6-45 p.m.

15th Coventry Section. A lecture will be given by E. Ingham' B.Sc., on "Modern Mining Machinery," at the Coventry Technical College, Room A5, at 6-45 p.m.

18th North-Eastern Graduate Section. A lecture will be given by A. C. Foskew, Int. A.M.I.P.E., on "Inspection Methods and Their Applications," at the Neville Hall Mining Institution, Newcastle-on-Tyne, at 6-30 p.m.

18th Halifax Section. A lecture will be given by H. C. Town, M.I.P.E., on "Hydraulics as Applied to Machine Tools," at the Technical College, Halifax, at 7-00 p.m.

18th Derby Sub-Section. A lecture will be given by I. S. Morton, Esq., on "Drilling Research," at the School of Art, Green Lane, Derby, at 6-30 p.m.

20th Sheffield Section. A lecture will be given by A. H. Jay, Ph.D., M.Sc., on "Application of X-Ray to Industrial Problems," at the Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

20th Manchester Section. A lecture will be given by K. J. Hume, B.Sc., A.M.I.P.E., on "Precision Measurements by Optical Methods," at The College of Technology, Manchester, at 7-15 p.m.

21st Wolverhampton Section. A lecture will be given by H. Fairbairn, A.M.I.P.E., on "Latest Developments in Die Castings," at the County Technical College, Wednesbury, at 6-30 p.m.

21st North-Eastern Section. A lecture will be given by J. H. Stanniers, Esq., on "Surface Grinding," at the Newcastle and Gateshead Gas Co's. Demonstration Theatre, St. John Street, Newcastle-on-Tyne, at 6-30 p.m.

21st Glasgow Section. A lecture will be given by R. J. Hird, B.Sc., on "The Production of Coal Cutting and Handling Machinery," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

February Meetings—*Cont.*

22nd Lincoln Sub-Section. A lecture will be given by A. P. Young, Esq., O.B.E., on "Managerial Problems during the Transition Period," at the Lincoln Technical College, at 6-30 p.m.

23rd Yorkshire Graduate Section. A lecture will be given by J. E. Hill, M.I.P.E., A.M.I.Mech.E., on "The Production of Fine Finishes," at the Great Northern Hotel, Bradford, at 2-30 p.m.

— Wolverhampton Graduate Section. A lecture will be given by J. Styles, Esq., on "Design and Manufacture of Special Cutting Tools," illustrated with drawings and specimens, at the Dudley and Staffordshire Technical College, Dudley. Full details not yet available.

March Meetings

4th Coventry Graduate Section. A meeting will be held at the Technical College, Coventry (Room A5), at 6-45 p.m., when "Short Papers" will be read.

4th Yorkshire Section. A lecture will be given at the Hotel Metropole, Leeds, at 7-00 p.m., on "Incentives in Industry." Speakers: Messrs. J. E. Hill, B. McMahon and L. J. Serjeant.

9th Yorkshire Graduate Section. Visit to The Kirkstall Electric Power Station, nr. Leeds, at 2-30 p.m.

12th North-Eastern Graduate Section. A lecture will be given by H. W. Kirkby, Esq., of the Firth-Brown Laboratories, on "War Development of Alloy Steels," at the Newcastle and Gateshead Gas Co.'s Demonstration Theatre, St. John Street, Newcastle-on-Tyne, at 6-30 p.m.

12th Luton and District Section. A lecture will be given by Mr. Parr on "The Future of Television," at The Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

13th Wolverhampton Section. A lecture will be given by H. A. Drane, Esq., on "Machine Tools," at the Wisemore School, Walsall, at 6-30 p.m.

13th Preston Section. A lecture will be given by J. E. Southcombe, M.Sc.Inst.Pet., on "Recent Developments in Lubrication," at the Municipal Technical College, Manchester Road, Bolton, at 7-15 p.m.

March Meetings—*Cont.*

14th South Wales and Monmouthshire Section. A lecture will be given by Dr. D. F. Galloway, Wh.Sc., A.M.I.Mech.E., A.M.I.E.E., B.Sc.(Hons.), on "Surface Finish in Practice," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

14th Manchester Graduate Section. General Meeting, followed by a lecture on "Gear Cutting," by A. S. Rowley, B.Sc., at the College of Technology, Manchester.

14th London Section. A lecture will be given by A. E. McRae-Smith, M.A., on "Modern Cast Irons," at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, at 6-30 p.m.

14th Leicester and District Section. A lecture will be given by E. Percy Edwards, Esq., on "Broaching and Broaching Machines," illustrated by lantern slides, at the Leicester College of Technology, at 7-00 p.m.

15th Birmingham Section. Annual Dinner Dance at the Botanical Gardens, Edgbaston.

15th Coventry Section. A lecture will be given by F. T. Dean, A.M.I.Mech.E., on "Conveyor Systems in Production Engineering," at Coventry Technical College (Room A5), at 6-45 p.m.

15th Western Section. A lecture will be given by T. H. Leitch, A.M.I.P.E., on "Die Construction for Plastic Moulding," at the Grand Hotel, Broad Street, Bristol, 1, at 6-45 p.m.

18th Derby Sub-Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Time Factor in Industry," at the School of Art, Green Lane, Derby, at 6-30 p.m.

18th Halifax Section. A lecture will be given by S. A. Woodo, Esq., on "Colour Schemes for Factory and Machines," at the Technical College, Huddersfield, at 7-00 p.m.

20th Manchester Section. Annual Meeting, followed by a lecture on "Cold Heading and Thread Rolling," by T. C. Parker, Esq., at the College of Technology, Manchester, at 7-15 p.m.

20th Sheffield Section. A lecture will be given by H. Burden, M.I.P.E., on "Developments in Tungsten Carbides," at the Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

20th Birmingham Section. A lecture will be given by W. W. Taylor, Esq., on "Modern Milling Practice," at the James Watt Memorial Institute, at 7-00 p.m.

March Meetings—*Cont.*

21st Glasgow Section. A lecture will be given by M. B. Hamilton, A.M.I.Mech.E., on "Design for Welding, with particular reference to High Pressure Vessels," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

23rd Manchester Graduate Section. Visit to Barlow & Chidlaw, Ltd., Salford.

28th Cornish Section. A lecture will be given by Dr. D. F. Galloway, Wh.Sc., A.M.I.Mech.E., A.M.I.E.E., B.Sc.Hons., on "Production Engineering Research," in the Lecture Hall, Cambourne School of Mines, at 7-15 p.m.

29th Lincoln Sub-Section. A lecture will be given by R. E. Reason, A.R.C.S., on "Super Finish and Its Measurement," at the Lincoln Technical College, at 6-30 p.m.

29th Manchester Section. A lecture will be given by Messrs. J. S. Jones and P. M. Walker, on "Electrodeposited and Allied Finishes," at the Mechanics Institute, Crewe, at 7-15 p.m.

29th North-Eastern Section. A lecture will be given by J. M. Gray, Esq., on "The Production of Pneumatic Tools," at the Newcastle and Gateshead Gas Co.'s Demonstration Theatre, St. John Street, Newcastle-on-Tyne, at 6-30 p.m.

30th Nottingham Section. A lecture will be given by H. Martin, Esq., on "Latest Developments in Welding Technique," at the Demonstration Theatre, Corporation Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

30th Manchester Section. A lecture will be given by Messrs. J. S. Jones and P. M. Walker, on "Electrodeposited and Allied Finishes," at Liverpool University, Brownlow Hill, Liverpool, at 2-30 p.m.

February Committee Meetings

12th Education Committee, at 10-30 a.m., at the Queen's Hotel, Birmingham.

12th Membership Committee, at 12-30 p.m., at the Queen's Hotel, Birmingham.

— Research Committee, at 11-45 a.m., at Loughborough College, Loughborough, Leics.

February Committee Meetings—*Cont.*

15th Finance and General Purposes Committee, at 2-30 p.m., in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

Technical and Publications Committee meet every Wednesday at 5-30 p.m. in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

Until further notice, meetings of the Finance and General Purposes Committee, the Technical and Publications Committee, and the London Section Committee will be held in the TEMPORARY Committee Room at 36, Portman Square, London, W.1. All correspondence is still to be addressed to No. 10, Seymour Street, London, W.1.

Council Meeting

The next meeting of the Council will be held on Friday, 22nd March, 1946, at 11-00 a.m., at the Institution of Civil Engineers, Great George Street, London, S.W.1.

SHREWSBURY SUB-SECTION. On Saturday, 15th December, 1945, A. W. Wallbank, B.Sc., gave an excellent lecture entitled "Protective Metal Finishes," at the Technical College, Shrewsbury.

The lecture was followed by an interesting discussion.

Letters of thanks have been sent to Mr. Wallbank and to Mr. A. Moore, Principal of Shrewsbury Technical College.

The Committee of this Sub-Section are now considering the advisability of holding these lecture-meetings on weekday evenings (excluding Saturday), as it is thought that the attendance might thereby be improved.

Personal

Mr. H. W. Bowen, M.I.P.E., has been appointed Managing Director of the newly-formed Company, E.M.I. Factories, Ltd., of Hayes, Middlesex, and Mr. T. W. Price, M.I.P.E., and Mr. J. B. Stevenson, M.I.P.E., have been appointed Directors.

Obituary

We deeply regret to record the death of Mr. J. A. Boyes, M.I.P.E., after a short illness. For many years instructor in mechanical engineering and drawing at Coventry Technical College, Mr. Boyes was an active member of the Institution and was President of the Coventry Section 1937-38. At the time of his death, he was a member of the Coventry Section Committee, and also of the Education Committee.

Association of Technical Institutions

The Annual Meeting of the Association of Technical Institutions will be held at the Regent Street Polytechnic, London, on 22nd February, 1946, when a paper on "The Training of the Production Engineer," will be read by Sir Robert McLean, President of the Institution.

In consequence of arrangements kindly made by Dr. Schofield, Vice-Chairman of Council, to whom the Institution is very much indebted for his efforts, it will be possible for a delegation of members of the Institution to attend this meeting, which affords an admirable opportunity to contact the heads of technical educational institutions throughout the country.

Any member who would like to take part and support the President on the question of technical training would be welcome, and should get in touch with his Section Hon. Secretary.

American Society of Tool Engineers

The Council has pleasure in recording that during his recent visit to America Mr. E. W. Hancock, M.B.E., M.I.P.E., President of the Wolverhampton Section, made the personal acquaintance of Mr. Otto W. Winter, National Chairman of the Education Committee of the American Society of Tool Engineers, whose position in the United States corresponds to that of the Institution of Production Engineers in Great Britain, and who have honoured us by inviting a representative member of the Institution to speak at the Society's first post-war Convention and Exposition at Cleveland, Ohio, in April, 1946.

Mr. Winter, in extending the invitation, said that a message from one of their British brothers as to what had been accomplished across the ocean in respect of Production and Tool Engineering Education would be a positive inspiration to them and commented on the remarkable achievements of the Institution in attaining professional recognition and respect.

He went on to say that his Society thought so highly of what a representative of the Institution might accomplish in outlining a challenge and proof of what can be done, that it would be the outstanding feature of their entire Convention.

Although it is doubtful whether this invitation can be accepted, the Institution's deep appreciation of this gesture has been expressed to Mr. Winter, and it is felt that the maintenance of such a contact by the interchange of literature, data and ideas will prove of great practical value.

Turner and Newall Research Fellowships

In recognition of their belief that mutual dependence between universities and industry is increasing, the Directors of Turner &

Newall, Limited, are providing funds for eight Research Fellowships in Engineering, Inorganic Chemistry or Physics, or allied sciences, of normal value of £600 per annum each, to be financed by them for seven years, and to be known as "Turner & Newall Research Fellowships."

The Fellowships will be established in areas containing certain of the Company's larger factories, the distribution being: Manchester University—four; University of London—two; Leeds University —one; and the University of Durham—one.

Important.

In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

Issue of Journal to New Members.

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

Books Received.

Deep Drawing and Pressing of Aluminium Alloys. Published by the Aluminium Development Association.

PRESIDENTIAL ADDRESS TO COUNCIL

28th September, 1945.

In addressing the Council of the Institution of Production Engineers on the 28th September, 1945, the President, Sir Robert McLean, said: "I suggested at the last Council Meeting that the Institution should take stock of its position and consider very carefully what its future policy should be. Since then the war with Japan has ended, and the first Socialist Government has taken office with a programme of nationalisation. Lease-Lend has been terminated, and a grim picture of the economic future is slowly being disclosed. Hence it is more than ever necessary for the Council to consider what the Institution's functions are to be in the years which lie ahead.

The Institution has a widespread membership and its proceedings are interesting and valuable, but there has been little in its lectures and papers which is peculiar to the Institution of Production Engineers. I feel that the Institution should now carve out a territory specifically its own in the engineering world, and become the source to which its members and the general public can look for education and information on the problems of competitive production.

The Production Engineer is in for a very rough time. This country will have to sell competitively against America, and do so apparently with the same set-up in the engineering industry as in the past. If this is done successfully, labour will claim the credit and the reward. On the other hand, if there is failure, the Production Engineer will get the blame. Therefore methods must be found for investigating the problems of the engineering industry in the post-war conditions of competition, establishing the facts, and publishing them, so that members of the Institution can have the information and the public be made conversant with the truth. Politics are coming into the heart of industry, and unwise things may be done without effective protest unless the public are fully informed of all the implications.

There is no body more capable of doing what is wanted than the Production Engineers. They know the impact of the present set-up on costs, and can speak with the authority of a professional body on other relevant matters. But there is at present no machinery in the Institution for arriving at the data and placing it and the conclusions before the public.

Most of the members of the Institution are full-time employees and not on the Boards of Directors of engineering companies. Not infrequently in the case of the larger concerns, there is no Director on their Boards with wide technical knowledge of the problems of production, so that on the full-time employees is laid

the burden of recommending production policy for the future. They have little say in the decisions, and their reward is small, but the onus of avoiding failure rests on them and they therefore become the victims of such failure. One of the great weaknesses of industry today is, in my view, that the pioneers of the past, who put this country on the top of the engineering world, have died out, and their places have been taken by Joint Stock Companies. Thus industry tends to get into the hands of chartered accountants, bankers, eminent public servants and so on, leaving in a subordinate position the man with the technical understanding and knowledge to frame a wise policy and with the courage not lacking among engineers to take the responsibility and see it through. It may be that the scarcity of such men at the top is responsible for the somewhat static state of affairs which has been frequent in engineering for the last twenty years.

I believe that the Institution of Production Engineers is the proper training ground for the type of man who, in the highest directorial posts, might restore to this country the technical leadership we once enjoyed. It is vital to our full recovery.

I suggest therefore that the time has come when the Council should discuss the whole situation, examine its past policy and plan for the future in the light of the situation which has to be faced. We are living in times of great changes and new problems in production. Now is the time to take stock of the place of the Institution in the scheme of things, of its aims and objects, and of its existing activities and each new one as may seem appropriate to the circumstances of these times.

If the Council decide that a new and clear statement of aims and objects, new Articles of Association, or a new policy is necessary, I feel sure that the members will welcome such action."

ANNUAL GENERAL MEETING

Friday, 14th December, 1945

The Annual General Meeting of the Institution was held at the Institution of Civil Engineers, Great George Street, London, S.W.1, on Friday, 14th December, 1945, at 10-30 a.m. Sir Robert McLean, President, occupied the chair.

Notice Convening Meeting.

The DIRECTOR-GENERAL SECRETARY, Major C. B. Thorne, M.C., read the Notice convening the Meeting.

Minutes.

The Minutes of the previous Annual General Meeting were taken as read, confirmed and signed.

Election of Members of Council.

The DIRECTOR-GENERAL SECRETARY read the list of Officers and Members of Council for 1945-46.

Presidential Address.

The PRESIDENT, Sir Robert McLean, delivered the following address :—

" Last year I claimed the privilege, as your President, of giving an address at the Annual General Meeting, and I propose to follow that precedent this year, on the clear understanding that the views expressed are those of the President and do not commit the Council. As President, I feel that I am entitled to give you the experience of a long and varied life as applied to your particular problems.

" When I addressed you last year the war was still raging, though the end of the fighting in Europe seemed imminent. Since then hostilities in all theatres have ceased, and we are entering upon a period of reconstruction of our industry at a time of immense economic difficulty and privation, and with conditions encircling us such as this country has never known before. We have to build up an enormous export trade in the future. Many percentages have been bandied about as to what this amounts to. I made an estimate last year from which I see no reason to depart, and came to the conclusion that if the White Paper on Unemployment and the Social Services was to take effect we must multiply our physical exports two and a half times. I see no reason to modify that estimate, if the White Paper be our objective.

" The debates in Parliament have shown how near we were to privation unless aid came to us from abroad. We have been com-

pelled to take a loan which may prove to be quite inadequate, on almost any terms. However we may regard that loan, it does nothing more than afford a breathing-space in which we should reconstitute the competitive basis of the engineering industry, and be prepared for the most resolute competition in the export drive from the United States.

"We are in a position where much of our engineering plant was obsolete before the war, and new plant worked under war conditions cannot be in proper condition. We are faced with the problem, with narrow resources in terms of dollars, of re-equipping the whole of our manufacturing industry. Every production engineer must be giving serious thought to this problem of re-equipment, because plant user and plant obsolescence are very large elements in the cost of finished goods. The ideal is to work high-speed plant as nearly as possible continuously, and to throw it out and replace it when it is not in 100 per cent. condition ; but I take it that while there is this shortage of foreign currencies, the tendency will be to put down the minimum amount of plant for manufacturing purposes and to work that plant for the maximum number of productive hours.

"This at once raises the question of whether we can revive our competitive power against the American export drive on the pre-war basis of one shift working a 47-hour week, with a very unsatisfactory half Saturday. Personally, I doubt it ; I believe that low machine hours will push up costs in export business and lead ultimately to wage reductions. High wages can come only from the efficient utilisation of machines and from a change in past practices with respect to shift working on the part of both trade unions and employers. There are, in my view, very many cases in the engineering industry where two-shift working on a five-day week would halve the cost of re-equipment, permit a high wage to be paid even against competition, and ensure that modern high-speed plant was kept in first-class condition. Re-equipment is the first step in the revival of our trade, and I submit that an investigation of this problem is very urgently needed and should be launched as early as possible. It is a piece of work to which this Institution and its members could make a very notable contribution.

"I make no excuse for referring here to the functions and duties of the production engineer in our engineering industries. In his technical training he lays his technical engineering foundation by mastering the technique of mechanical and electrical engineering, and this Institution also adds its quota to his training. It is then his duty to synthesise that knowledge with whatever useful knowledge he can take from physics and chemistry, with one main object : to offer to consumers an article of high quality at the lowest possible cost in capital equipment and revenue expenditure.

"Wage rates and relations with labour are not the least of his problems. He must favour high earnings for his people, but he must also ensure that high production which alone can justify such wages. Nor is he dealing with industrial and economic problems alone. The trade union movement is declaredly political as well as industrial, and we all have experience of how these two factors are intertwined in the problems of the shops. Whether the struggle between one political theory and another in the unions themselves is compatible with ordered industrial recovery remains to be seen. The evidence so far would be against it.

"I have defined—quite inadequately, I admit—the functions of the production engineer, and it is reasonable to ask what special help the Institution can and should give to him in the discharge of what is a public duty, and to ask also what service the Institution can render as a professional body to the public. Granted that the basic training of the production engineer is shared with other Institutions, there is a great territory in the politico-economic aspects of engineering production which has hardly been touched. Very little work has been published in this or other countries making comparative analyses of organisational methods, costs, bonus practices, and the results or the impact of machine user and obsolescence on costs and wages. This and much more might and should become the special territory of this Institution. Armed thus by the Institution, our members should reach the highest posts in the engineering industry.

"The Institution has also, I submit, a duty to the public. In the years to come, much public notice will be directed by economic difficulties to our competitive power in the engineering and other trades. Through papers by its members and the work of well-chosen research teams this Institution can give a service of inestimable value by establishing the relevant facts and releasing them to the Press and public in a form easy for the non-technical to understand. I hope there will come a day when Press and public alike look to this Institution as the authoritative body from which informed opinion and proven facts emanate on the subject of competitive trade in engineering products.

"We are 25 years old and the time is ripe, I believe, for the Institution to re-examine its place in the scheme of things and in the light of that examination to re-define if necessary its objects and reasons, and set up an establishment equal to the discharge of these functions and duties." (*Applause.*)

Annual Report and Accounts.

The CHAIRMAN OF COUNCIL, Mr. J. E. Blackshaw, presented the Accounts of the Institution for the year ending 30th June, 1945, and

read the Annual Report of the Council, including the Annual Report of Research Department, as follows :—

Unification of Screw Threads between Great Britain, Canada, and the United States of America.

The Institution was strongly represented at a Conference on the Unification of Screw Threads between Great Britain, Canada and the United States, held at the Institution of Mechanical Engineers on 22nd June, 1945, with a view to ascertaining the opinions of engineers throughout this country on this vitally important subject. As it was felt that the Institution might render valuable service by putting forward the representative opinion of its members, all sections at home and abroad were therefore asked for a comprehensive statement of their views. Since the end of the financial year several sections have sent in full reports of their members' discussions on this question, and others have intimated that they will do likewise.

Research.

At a special meeting of Council held in November 1944, the whole question of Research was considered, together with the possibility of establishing a more comprehensive Research organisation to include, in addition to this Institution, the M.T.T.A., the Gauge and Tool Makers' Association and the National Federation of Engineers' Tool Manufacturers. Since then much progress has been made, and it is hoped that finality will be reached in the early part of 1946. An appeal was made this year for funds to finance the Institution's own Research Department during the interim period.

Annual Report of Research Department.

During the year, sixteen private research reports have been issued on investigations completed by the Research Department. These investigations covered a wide range, including rough turning tests, finish turning tests, rough milling tests, finish milling tests, drilling tests, tests for various cutting oils, and a wide range of cutting tools, including carbide tools and high-speed steel tools. Tests on new types of special grinding wheels have also been carried out. Investigations on machine tools for vibration, deflection, efficiency and general performance have been conducted both in the Research Department and in Industry through the field research section. Investigations on surface finish have also been continued. Some of the work during the past year has been described in periodic reviews of Research Department activities and in papers, particularly the paper "Production Engineering Research." Publications in print include "Standardisation and Practical Application of Cutting Tool Nomenclature," "Machine Tool Research and Development," "Practical Drilling Tests," and Acceptance Test Charts for Machine Tools, Parts 3 and 4.

Co-operation with H.M. Government regarding rehabilitation of ex-officers.

The Institution was represented by Mr. E. J. H. Jones and the Director-General Secretary at a conference on this important subject called by the Ministry of Labour on 1st June 1945. A full report was made to Council, and Mr. Jones was asked to prepare a memorandum which was subsequently presented to the Ministry.

Australia.

In accordance with the decision of Council in June, 1944, an Australian Sub-Council was established in December of last year and is now functioning. The Sydney and Melbourne Sections of the Institution are steadily expanding and the formation of a further section at Adelaide is under consideration.

India—Calcutta Section.

During the year the Council authorised the formation of a Section in India, and Mr. J. D. Scaife was asked to supervise its establishment during his visit to that country.

United Kingdom Sections.

Since the last Report, the Nottingham Section has formed a Sub-Section at Derby, and its inaugural meeting was held on 20th November, 1944, when Mr. H. J. Swift was installed as first Chairman. The Wolverhampton Section has formed a Sub-Section at Shrewsbury, and the Mayor of Shrewsbury presided at its first meeting on 20th January, 1945. The North-Eastern and Manchester Sections have each formed Graduate Sections during the year, and these held their first meetings on 7th and 15th November, 1944, respectively.

Growth of the Institution.

The membership of the Institution has increased by 760 members during the financial year. The total membership as at 30th June, 1945, was 5,219, as compared with 4,459 in June, 1944. This figure is made up as follows :—

Honorary Members	3
Members	972
Associate Members	1,616
Associates	119
Int. Associates	992
Graduates	692
Students	618
Affiliated Representatives ...	207
Total ...	5,219

Obituary.

We deeply regret having to record the death of Commander Sir Charles Craven, R.N., Hon. M.I.P.E., President of the British Employers' Association and Chairman of Messrs. Vickers Ltd. He was also Industrial Adviser to the Minister of Production. His contribution to Britain's industrial effort entitles him to be regarded as one of the country's most outstanding engineers.

We also record with regret the deaths of the following members: Messrs. R. W. Cavey, A.M.I.P.E., C. W. Collier, M.I.P.E., H. C. Collins, A.I.P.E., G. H. Drake, M.I.P.E., W. Duxbury, M.I.P.E., A. G. Engwell, M.I.P.E., E. P. Graham, A.M.I.P.E., L. A. Gregg, A.M.I.P.E., H. W. Healy, M.I.P.E., W. Howells, Int. A.M.I.P.E., L. J. Kaye, M.I.P.E., C. H. K. Lucas, A.M.I.P.E., A. I. Murdock, A.M.I.P.E., C. B. Northey, M.I.P.E., H. O. Page, A.M.I.P.E., H. G. Rawlings, Int. A.M.I.P.E., E. D. Rickards, A.M.I.P.E., A. J. Rogers, A.I.P.E., H. Scaife, M.I.P.E., C. F. W. Snoxell, A.M.I.P.E., J. A. Southcott, A.M.I.P.E., L. L. M. Wilson, Int. A.M.I.P.E., I. H. Wright, M.I.P.E., and in Australia, P. Smith, M.I.P.E.

Honours conferred on Members.

It is with pleasure that we record the following honours conferred upon Members of the Institution by H.M. the King:—

T. C. L. Westbrook, C.B.E.

B. Haviland, O.B.E.	B. W. M. Wakefield, M.B.E.
W. G. Bennett, M.B.E.	J. M. Lawrence, M.B.E.
S. H. Brewell, M.B.E.	F. H. Moorman, M.B.E.

Trustees—Retirement of Mr. J. A. Hannay.

It is with great regret that we have to announce the retirement of Mr. J. A. Hannay from the office of Trustee to the Institution. Mr. Hannay, who acted as Chairman of Council in 1929, is one of the oldest Members of the Institution, and now that he is relinquishing his office the Council wish to express their thanks and sincere good wishes to him for the future. The present Trustees are Mr. J. E. Blackshaw, Chairman of Council, Mr. J. G. Young and Mr. T. Fraser.

Education.

Lord Austin Prize.—The Lord Austin Prize for 1944 was awarded to Mr. W. Johnson, Grad. I.P.E. for his paper on "An Ideal Training for Apprentices," and also to Mr. A. B. Dear, Grad. I.P.E., for his paper on "Tooling-up and Equipment for New Contracts."

Graduateship Examinations.—Examinations were held in May and

June of this year at 20 different centres. Of the 50 candidates who presented themselves, 29 passed, 12 failed and 9 failed in one subject but were given an opportunity of taking it again in 1946.

Higher Technological Training.—The report of the Lord Eustace Percy Committee on " Higher Technological Training " has now been published, and although Production Engineering as such is not mentioned, a good many of the suggestions included in our Memorandum on Technical Training are embodied therein.

Technical and Publications.

The activities of the Technical and Publications Committee have altered slightly with the end of the war. While their main object has always been the production of the *Journal*, during the war the Committee dealt with hundreds of technical enquiries on all subjects associated with Production Engineering. This service was given not only to members and member-firms, but was substantially extended to Government Departments. With the conclusion of hostilities, however, this service has greatly decreased, leaving the Committee free to deal with other important Institution activities.

Subsequent to the production of B.S.I. reports on Production Control, the Sub-Committee appointed to deal with this matter, although in recess, has kept the whole subject under careful review. Another important activity concerns the Library. Since all the existing volumes were destroyed by enemy action during the war, this problem has become acute. In preparation for such developments as may arise, the Committee have compiled a list of technical works which it would be advisable for the Institution to acquire.

The standard of technical papers given to the Institution and its Sections has been the constant care of the Committee, and with this in mind two conferences with Section officers have been held. The co-operation of all Section executives is earnestly sought in this matter.

Finance.

The finances of the Institution are as follows: The excess of Income over Expenditure as at 30th June, 1945, was £3,474 1s. 6d., against a deficit of £450 10s. 7d. at 30th June, 1944. This improvement is attributable to the increased rates of subscription together with an increase in membership.

Appointment of Director-General Secretary.

The new Director-General Secretary of the Institution, Major C. B. Thorne, M.C., took up his appointment on the 12th March of this year, following the resignation of the General Secretary, Dr. K. G. Fenelon, and the Technical Secretary, Mr. F. Gibbons.

Biographical notes relating to the new Director-General Secretary were published in the August, 1945, issue of the *Journal*.

Re-organisation of Head Office.

The head office of the Institution has undergone drastic re-organisation, and the new layout has been circulated to all Section Hon. Secretaries. As the present premises are inadequate, every effort is being made to repair the war damage at No. 36, Portman Square at the earliest possible date.

Thanks to retiring officers.

The Council wishes to record its appreciation of the services rendered to the Institution by the retiring Section Presidents and Members of Committees, and also wishes to thank the Section Hon. Secretaries for their wholehearted co-operation and their enthusiasm in discharging their duties during the past year.

The Report and Accounts were adopted on the motion of Mr. H. A. Hartley, seconded by Mr. E. J. H. Jones.

Progress Report by the President.

In presenting a short progress report, the President mentioned a few additional items, as follows :—

Mr. J. D. Scaife's visit to India.

Before Mr. Scaife left for India, some useful work was done by the National Press of India, who co-operated very keenly in making the visit a success. One of the objects of his visit was to form a Section in Calcutta, and Mr. Scaife has reported that there is a great opening for such a Section.

Association of Technical Institutions.

Dr. Schofield, Vice-Chairman of Council, has arranged for a delegation of members of the Institution to attend the Annual Meeting of the Association of Technical Institutions to be held in London on February, 22nd, 1946. A paper entitled " The Training of the Production Engineer " will be read by the President of the Institution, and an admirable opportunity will be afforded for conferring with the heads of technical educational institutions throughout the country. The Institution is very much indebted to Dr. Schofield for making these arrangements.

Co-operation with H.M. Government.

The Institution has been invited to co-operate with H.M. Government in the training of ex-Service men and industrial management.

Production Engineering Research Association of Great Britain.

Since the end of the Institution's financial year, further progress has been made in the formation of a proposed "Production Engineering Research Association of Great Britain." A "Shadow Council" has been formed which includes representatives of the Institution of Production Engineers, the Machine Tool Trades Association, the Gauge and Tool Makers' Association and the National Federation of Engineers' Tool Manufacturers, together with representatives of the Director of Scientific Research. For the first five years the Institution will nominate the Chairman, and Mr. F. W. Halliwell has been nominated to fill that position for the first year of the Association's legal life.

Research Fund.

As a result of the Institution's appeal for financial support for its Research Department the sum of £2,925 has been contributed by members. In addition the sum of 1,000 guineas has been generously donated by the M.T.T.A. towards current expenses.

Hazleton Memorial Library.

It is felt that the time has come for the Institution to express its appreciation of the services of its former General Secretary, the late Mr. Richard Hazleton, who did so much for the Institution in its early days. It has been decided to form a reference library, to be known as the Hazleton Memorial Library, as a fitting tribute to his memory. A Committee has been set up under the Chairmanship of the Rt. Hon. Lord Sempill, consisting of Messrs. Hales, Hartley, McLeod, and Kirchner, and an appeal will be made, early in 1946, to all members of the Institution to contribute towards its formation.

Re-organisation of Head Office.

The Chairman has already referred to the re-organisation of the head office by Major Thorne, who has reported that the work done by the staff and their loyalty to the Institution has been beyond all praise. Major Thorne has never had occasion to ask for extra hours to be worked ; members of the staff have always volunteered to stay as long as might be necessary to do whatever is required. There is no doubt that the head office of the Institution is now in a very much healthier and more efficient condition than before, and I feel sure that members would wish me to express to Major Thorne and his staff their high appreciation of the work that has been done. (*Applause.*)

Election of Auditors.

On the motion of Mr. J. E. Blackshaw, seconded by Mr. G. H.

Hales, Messrs. Gibson, Appleby & Co., Chartered Accountants, were re-elected Auditors to the Institution for the year 1945-46.

Vote of Thanks to Section Hon. Secretaries.

The PRESIDENT moved a vote of thanks to the Section Hon. Secretaries. The Institution, he said, derived its strength largely from being a federation in which the Sections were in a sense self-governing. They were territorial by nature, and on their keenness and enthusiasm depended the metabolism of the body of the Institution. The Section Secretaries had as a rule a thankless task ; they were responsible for all the arrangements and carried on all the correspondence, and the only recompense which could be given them was to tell them once a year at the Annual General Meeting how warmly their efforts were appreciated and how deeply indebted the Institution was to them.

The vote of thanks was carried with acclamation, and the meeting then terminated.

APPLICATIONS FOR MEMBERSHIP AND TRANSFER RATIFIED AT THE DECEMBER COUNCIL MEETING.

* Applicants elected by the Council.

As Members: J. E. Attwood, F. W. Buglass, F. Caunce, A. W. MacFerson, R. J. Mitchell, E. N. Vincent, S. Walker.

As Associate Members: E. H. Adams, A. T. Allsop, F. C. Baggett, G. L. A. Cherrington, B. D. Davis, C. J. Day, R. Eastwood, J. N. Eden, E. J. G. Granger, R. W. Gunton, J. Hanna, J. W. Haslam, L. W. Holton, C. B. Hoole, W. Irving, E. J. Keane, H. G. Kilgour, E. Knight, A. P. Lee. J. Levisohn, F. R. Matthews, D. Mettrick, J. B. Montgomerie, D. Munro, J. H. McDonald, G. J. MacPherson, E. I. Nash, *J. C. Norris, J. B. Scott, P. T. Silvers, A. A. Stanley, S. G. Statham, J. H. Stevens, J. H. Taylor, R. Telford, A. J. Thompson, *C. Timms, A. W. H. Walker, C. M. Walker, W. H. Warburton, A. F. Wilby, J. L. Wilkinson, T. H. Williams, T. G, Woodward, C. E. Wright.

As Associates: J. Erskine, W. J. Hargest, F. W. Jackson.

As Intermediate Associate Members: L. T. E. Alexander, J. W. Baker, F. C. Bambridge, H. C. Bew, K. A. Blacklock, R. J. Boff, R. H. F. Bone, C. T. Bower, R. J. W. Brown, G. H. Burns, W. N. Chalker, W. B. Coles, L. A. Cox, F. G. Cresswell, C. A. Currier, J. R. W. Danks, G. H. Dean, R. V. Field, H. J. Fricker, H. Fulton, G. Gibson, *D. O. C. Hall, G. E. N. Hall, J. L. Halmshaw, G. J. Harrop, S. C. Hodgson, N. C. Holmes, F. R. Humphrey, J. Hunter, H. Johnson, W. Johnson, H. L. Juliusburger, A. R. Jupp, F. Kemsey-Bourne, S. A. King, J. W. Leach, J. E. Lissaman, *F. C. Manser, W. McAllister, N. McD. Taylor, C. R. Nuttall, J. C. Partridge, *A. Pugh, D. G. Rees, R. Rees, G. T. Roebuck, H. Speed, N. Travis, E. G. Vincent, E. Wilkinson, W. H. Willis.

As Graduates: W. R. Allen, J. T. E. Bennett, B. R. Bensly, E. J. Bradley, G. S. Brosan, J. L. Caine, P. J. Campbell, P. A. Clennell, G. A. Clough, R. Clucas, E. A. Conway, W. Edden, R. W. Gilkes, R. Hallam, G. Harrison, P. R. Hosken, K. T. Jackson, F. Johnson, J. Joyce, E. J. Keane, B. M. Keen, J. E. B. Kiddell, H. Killingback, J. Killingback, S. Langham, H. Mawson, R. Mein, J. McLeman, L. McPherson, G. A. Napier, W. C. Nicoll, G. W. Payne, R. G. Poyser, L. Rushton, F. W. Slater, R. J. Slide, N. H. Soulsby, R. W. Sturges, H. Summerfield, W. Thompson, T. D. H. Thorp, S. H. Thurgar, F. W. Watson, C. Withington.

As Students: R. Ansbacher, G. R. Atkinson, M. Barker, E. B. Bates, S. R. Bates, E. W. Beever, R. Broaderwick, R. B. Brown, J. W. Burton, B. N. Cooper, P. J. Dannhorn, L. S. Davey, G. L. Elsworth, D. H. Freeman, *P. G. Glew, A. Griffiths, D. Hamlyn, D. A. Hardcastle, J. D. Harrison, I. J. C. Kent, T. Lewins, P. C. D. Mace, M. P. Marsh, D. C. McKie, W. Nicholson, W. J. O'Brien, A. Ormondroyd, W. L. Pace, E. Page, Jnr., G. C. R. Parr, R. G. Powell, R. Scott, K. S. Smith, A. Sumner, D. E. Taylor, L. Taylor, R. H. J. Tyson, B. A. Winkfield, F. H. Willetts, C. F. Whittingham, G. H. Whyatt.

As Affiliated Firms:	New Affiliated Representative:
Austin Motor Co. Ltd.	G. W. Harriman.
Blackburn Aircraft Ltd.	T. Bancroft.
Carbodies Ltd.	J. H. Orr.
Dean, Smith & Grace Ltd.	B. Laycock.
Deloro Smelting & Refining Co. Ltd.	G. E. Bell H. T. Gittings.
Gent & Co. Ltd.	H. K. Parsons.
Hayward-Tyler & Co.	E. Thompson.
Howard & Bullough Ltd.	J. W. Ford. J. Skinner.
Humber Hillman Ltd.	H. D. S. Burgess. R. G. Leaf.
Jos. Lucas Ltd.	A. W. Rollason. W. R. Russell.
Macrome Ltd.	G. F. Thick.
C. A. Parsons & Co.	W. Winter.
S. Russell & Sons Ltd.	D. M. Mercer.
Sanderson Brothers & Newbold Ltd.	W. G. Wallace.
Simms Motor Units Ltd.	R. J. P. Brealey. W. Bryan.
Edgar Vaughan & Co.	S. J. Davies.
Watliff & Co.	W. E. Arnold.
Wild Barfield Electric Furnaces Ltd.	J. E. Oram.

TRANSFERS.

From Associate Member to Full Member: W. A. Bothwell, W. Fletcher, R. H. Hancock, H. Johnson, F. H. Perkins, C. J. Swain.

From Intermediate Associate Member to Full Member: W. G. Davis.

From Intermediate Associate Member to Associate Member: N. R. Atkins, H. H. C. Brown, J. Cherry, E. A. C. Dell, A. R. Ellis, C. W. Godridge, E. S. J. Goodenough, G. S. Greenfield, *J. W. Lowe, N. J. Newbold, A. E. Stenning, R. H. Stenning, *C. S. Tarling, E. Woolley.

From Graduate to Associate Members: G. P. Archibald, A. H. Ashton, R. A. Cox, C. M. G. Calver, K. B. Haskins, E. Mells, J. N. Williams.

From Graduate to Intermediate Associate Member: A. F. Allen, A. E. Andrew, S. J. Dawson, A. J. C. Grant, S. Kilburn, F. R. Naylor, D. D. Oakley, L. J. Rose, F. E. N. Russell, R. R. Speck.

From Student to Graduate Member: G. Atack, D. Chamberlain, K. J. Foinquinos, E. Garside, K. L. Jackson, K. H. Jones, H. F. Mather, T. Marsden, A. H. Needham, A. P. Oppenheimer, K. A. Pratt, F. E. Rattlidge, J. E. Ullmann.

DISCUSSION ON "MODERN HEAT TREATMENT OF STEEL"

By A. Craig Macdonald, B.Sc., A.R.I.C., M.I.A.E.

Presented to the London Section on December 13th, 1945.

The CHAIRMAN, opening the meeting, said they were very fortunate in having with them Mr. Craig Macdonald, who was an expert in the field about which he was going to speak. Mr. Macdonald had come a long way to give the address, and he would call upon him straight away to read his paper on "Modern Heat Treatment of Steel."

(The paper, which was then read, was published in the January issue of the Journal.)

The PRESIDENT said they had listened to an address which was obviously delivered by an expert. He was sure it had been of great general interest to all present, and many members would want to extend what Mr. Craig Macdonald had said by discussion.

He had hoped that Mr. Kidd of the London Section would have been present to open the discussion, but unfortunately he had been precluded from coming. He had, however, sent along some comments which would be read by Mr. S. J. Davis, after which the meeting would be open to general discussion.

Mr. S. J. DAVIS said in contributing towards Mr. Craig Macdonald's excellent lecture he would read the following comments of Mr. Kidd who, unfortunately, could not be present.

"Mr. Craig Macdonald is to be congratulated on his paper for two reasons—firstly, because it presents an extremely interesting survey of modern trends and, secondly, because he has had the courage to tell Production Engineers something of the specialized technique which will shortly be an essential part of normal heat treatment.

"These recent developments have become common topics amongst metallurgists, but very few have yet braved the Board Room with requests for the allocation of money for the new equipment. It is my firm conviction that few engineering companies can afford to disregard these developments and I hope this paper may have helped to bridge the gap between completed research and practical application.

"Mr. Macdonald has given some very interesting facts regarding the use of 'S' curves in heat treatment and has briefly mentioned the need for steels of specific grain size. As the result of a considerable number of isothermal treatment experiments, I should like to stress the importance of grain size control and ask Mr. Macdonald to outline the McQuaid-Ehn test for the benefit of our members.

"An important practical point in connection with the use of 'The Atlas of "S" Curves' is that one must not expect to obtain the indicated hardness figures as the result of quenching widely different masses of materials of varying grain size, from the specified hardening temperatures. As it is frequently necessary to use lower quenching bath temperatures, the exact figure should be determined by actual test on the size and type of material to be used.

"I am very glad to see Mr. Macdonald is encouraging the adoption of the Jominy test. The equipment required is very inexpensive, but the information produced is invaluable.

"With regard to sub-zero treatment, it is interesting to see that Mr. Macdonald recommends a process time of 4/6 hours at minus 120°F. for general work. While my personal experience indicates the value of prolonged treatments at this temperature, I have not had the opportunity to experiment with a ten-minute treatment in liquid oxygen, at approximately minus 300°F., which is claimed to give equally good results. In spite of the rapid cooling which accompanies this treatment, failures by cracking are apparently not experienced.

"Most American opinion on the subject indicates that temperatures below minus 120°F. have very slight additional value.

"If Mr. Macdonald has any experience of sub-zero treatments at these extremely low temperatures, can he tell us whether the claims which are made for them are likely to be substantiated and whether he considers the saving of time would justify what would appear to be an extremely costly process.

"I should also like to know whether, in Mr. Macdonald's opinion, the increase in hardness is due solely to the transformation of the retained austenite and, if so, how does he account for the considerable increase in case hardness resulting from the sub-zero treatment of a water quenched hypo-eutectoid carburized bar.

"Two points in connection with salt bath treatment may justify further comment. Firstly, the decarburizing of steel in neutral salts, although a serious problem in the past, is now, with modern salts, largely a matter of correct manipulation. Secondly, the somewhat lengthy procedure which has been outlined for the ageing of a nitriding bath, prior to its use on high-speed steel, may prejudice possible users against its adoption.

"Salts which can be put into immediate use are now marketed and it is claimed that they will produce equally good results over prolonged periods.

"Induction heating has undoubtedly come to stay and does, as Mr. Macdonald suggests, provide a means of heating large quantities of certain types of work, which is far superior to any other method. Its use for relatively small batches of varying types of work has produced unfair criticism and I should like to stress its high cost when incorrectly applied, so that Members will not be likely to be misled."

Mr. DAVIS said he would like to make one comment himself. The author mentioned that the only deep-freezing plant in this country had been supplied by America. He was sure, however, that the author would be glad to know that this country had now produced a refrigerating plant perfectly capable of doing sub-zero treatment. He had seen it and it worked very well down to minus 120°F. It was really a first-class job and it was nice to know that we could do it in this country.

He said the lecture had been most enjoyable and instructive as regards the introduction of modern methods of heat treatment into shops.

Mr. CRAIG MACDONALD said he was much obliged to Mr. Kidd and Mr. Davis for their remarks.

Mr. Kidd had asked him to outline the McQuaid-Ehn test for grain size, and there was no very great difficulty about that. Cementite, which he had mentioned, could be caused to segregate in the grain boundaries of steel and, when etched, because of its brilliant white colour, it showed up very readily. McQuaid, as a result of a large number of experiments, found that if steels were carburized in highly energised media, giving excess carbide in the case separating it in the form of cementite, the slow cooling in carburizing gave a fairly substantial grain size outlined by the cementite as already described, and as demonstrated by the slide which showed variations in grain size. If the treatment was standardised so that all conditions were the same for each specimen of steel examined, then the inherent grain size of the material could be compared readily in that fashion.

They had not got much past the stage of buying two classifications, fine grain steel and coarse grain steel ; each with its own peculiar properties. The day may come, however, when they would be more definite and demand that grain size should be in very fine limits. To that extent he had to agree with Mr. Kidd.

He agreed, too, that after Jominy tests and other tests had been carried out it was desirable to compare results by actual test on the material of the part which you were going to use to confirm that you were going to get results that the tests suggested you might.

He was glad that Mr. Kidd agreed with the value of prolonged sub-zero treatment of tools. Like Mr. Kidd, he had not had an opportunity to experiment with the ten-minute treatment with liquid oxygen, but it happened that some tools for the purpose were in the hands of the Oxygen people that week, and he was hoping to get some interesting results when he returned to Glasgow.

He would add that with this sub-zero treatment, the danger of cracking, whilst it was not proving as serious as they might have anticipated, nevertheless was there. With the kind of refrigerating equipment he described it was possible to take tools down fairly slowly to sub-zero temperature, which helps a lot.

He was not familiar with the arrangements to use that medium for sub-zero cooling proposed by the liquid oxygen advocates. It would be safer to carry out the process without bringing the parts down violently to low temperature. He was not as optimistic as Mr. Kidd that serious cracking troubles would be avoided.

Mr. Kidd mentioned in connection with that process that he regarded it as extremely costly. He did not know that he agreed, because while the initial equipment, which he was glad to hear was now obtainable from British manufacturers, made the cost about £1,000, the cost of running it was quite small. One needed a couple of one-and-a-quarter horse power motors, and there was, of course, the consumption of electricity to keep the motors going. Apart from that very little other running cost was involved. Maintenance was negligible over a very long period. So while there may be a fairly high cost for the installation of the equipment, over a period, in relation to the number of tools that could be treated and the improvement that could be obtained, he suggested that except in a small shop the process was not necessarily fairly described as expensive.

He said Mr. Kidd also wanted to know whether the increase in hardness was due solely to retained austenite and, if so, how did one account for the increase in case hardness resulting from the sub-zero treatment of a water quenched hypo-eutectoid carburized bar. He would make no attempt to account for it at all, because he did not know that it happened.

Mr. Kidd also mentioned the decarburizing of steel in neutral salts, and suggested difficulties had been overcome with modern salts. He said it had yet to be demonstrated to him that that was so, and he heartily disagreed that it was a matter of correct manipulation. Secondly, Mr. Kidd said the somewhat lengthy procedure which had been outlined for the ageing of a nitriding bath might prejudice possible users against its adoption. He thought in the paper he mentioned something about 15 hours for the ageing of salt at nitriding temperature, and once it had aged it was aged for good.

He did not think after installing the equipment that anyone would be worried about the gas consumption for 15 hours in view of the improvement in tool life resulting therefrom.

He appreciated that salts which could be put into immediate use were now available, but the manufacturers were probably charging more than they were worth. He was glad to know that Mr. Kidd felt there was a great future for induction heat.

Mr. MARSHALL said he had known Mr. Macdonald and had worked with him for a number of years. He said the distinction between carbon and alloy steels was now becoming less clear owing to the method of steel manufacturers in using increasing proportions

of alloys. It had been the practice lately to use scrap containing any amount of alloy elements, and it had become a problem of considerable importance. From the practical aspect he would like to know whether the author felt his earlier remarks could be amplified on that matter.

His next point was that in America he believed they had gone far in investigating optimum machining conditions in all operations.

With regard to the properties shown for various limiting masses, of course by variation of temperature all properties were obtainable. It was not always clear that if you got 55 tons up to 4 in. you could also get it in smaller sections by varying temperature.

With reference to decarburisation they had actually been in the position of rejecting springs for being too soft, but on removing the skin they were rejected for being too hard.

With regard to the induction hardening process, there was an instance of it enabling them to carry out an operation which otherwise could not be carried out satisfactorily at all. Great difficulty had been experienced in getting rifle bores to satisfactory hardness, but the introduction of the induction hardening process enabled those parts to be dealt with satisfactorily.

One method of heat treatment which had not been mentioned was that of gas carburizing. In that connection great difficulty was being experienced in getting labour to return to the filthy carburizing shops. He felt that gas carburizing would have to be considered.

Mr. CRAIG MACDONALD replying, said the distinction between carbon and alloy steels he did not feel was so very difficult. An alloy steel is any steel containing sufficient alloy in the form of nickel, molybdenum, or other popular alloy element, obviously to affect the physical properties as compared with a carbon steel with the same carbon content. He trusted that most members would agree that that distinction might remain of assistance indefinitely.

He was interested in Mr. Marshall's remarks about optimum machining conditions, and he heartily agreed with him that in the United States an extraordinary amount of work had been done in that connection but in this country very little. They had got to a stage in some mass production shops in the United States where there was a heat treatment operation between every machining operation so that material should be in the best possible condition to make the next machining operation as simple as possible, with highest possible speeds, and to give the longest possible tool life. It was very difficult in the smaller units in this country to justify going to that length, but it had been found advantageous to do something along those lines.

As an example, 100 ton oil-hardened nickel chromium steel, used for automobile differential gears, was normally machined

throughout in the soft annealed condition then oil-hardened and finished by grinding. The broaching operation could be extremely troublesome, particularly if the steel was in a very soft condition which was so desirable for reasonable tool life in other operations such as turning. It had been found worth while when the broaching operation was reached to harden and temper the gears to a rather higher hardness than before and, instead of the broaching leaving a poor finish due to the soft steel tearing, they had a fine clean bore. The sort of figures he had in mind were hardnesses of the order of 255 to 277 Brinell which was quite good for the ordinary operations, and 320 Brinell for broaching purposes.

With regard to the springs that were too soft and then when the surface was removed were rejected because they were too hard, he appreciated that contribution, not only because it gave an excellent example of the matter he had described, but because it demonstrated so well that the inspector was mainly concerned with rejection in any case !

He felt a great deal more would have to be done in connection with the gas carburizing process. He had spent a lot of time trying to get equipment to improve conditions in the ordinary carburizing shop in his own works (which were good compared with others) and he felt that gas carburizing would get them out of a lot of trouble. Control was extremely difficult. You had always the danger of the gas produced from carbonaceous oil depositing soot on the parts and insulating them from the carburizing gases, and a much greater degree of technical skill was therefore required to operate it.,

The Ministry had fathered a most peculiar steel known as EN320. This steel had nice mechanical properties but was not much use to people like himself. By ordinary hardening methods it was impossible to avoid very heavy cementite with that steel, but it might be done by gas carburizing. He found if you took a piece of that steel and cut it in two, smoothed and polished one face of each piece, clamped them together, immersed the clamped specimens in a carburizing salt bath, and held them at carburizing temperature for say 1½ hours, they carburized rapidly except on the two surfaces clamped closely together. If at the end of 1½ hours, while still in the salt, you knocked away the clamps so that the pieces were separated and the flat faces got carburized, and you continued heating for another four or five hours, cooling in the ordinary way, you found with this particular steel that on the faces which were carburized from the beginning there was very heavy cementite, which made it useless for important applications, but on the flat faces which were held closely together for 1½ hours there was no cementite at all, indicating that if the steel was austenised for 1½ hours before carburizing is allowed to begin, you did not get the very heavy cementite deposits.

In ordinary carburizing treatments, parts could not be held at carburizing temperature for any time at all without getting them carburized, except by the impractical expedient which he had described. However, with gas carburizing plant this steel of which they were very suspicious at the moment might become very useful to automobile engineers.

Mr. ELSON said he was recently over in the United States and he came across two matters which he thought might be of some interest. One was that he had brought back with him some particulars of an electric salt bath where the electrodes in the salt bath were in the bottom of the furnace, which enabled them to manufacture a very long and narrow furnace and thus get rid of heat loss which normally came from opening the furnace. They also had with the furnace an electronic control with which they claimed they could hold temperature within two degrees at two thousand degrees.

The second point was in regard to retained austenite. He was with one firm who were having trouble with physical growth and shrinkage of materials. They were dealing in the particular instance with a gauge block about 12 in. long. This was in steel called Stenta, and it was found that it was shrinking in small amounts in the order of ten thous. In order to overcome that they gave it an oil boiling process and it seemed to stop. Then they found it was growing so it was put through the deep-freezing process and they found the large growth of 17/10 apparently from retained austenite.

Mr. CRAIG MACDONALD said he was very interested in the salt bath described by Mr. Elson, because tremendous use could be made of equipment of that kind with conservation of heat and reduction in cost of operation. Economy would have great bearing on the extent to which British engineers and heat treatment specialists would use the salt bath for heat treatment process, and improvements of the kind described were thoroughly desirable.

As far as alteration to size of gauges was concerned—and they knew how important that was—he quite appreciated the probability that in water-hardened steel of the type described quite a variation in size with time could be experienced. Unfortunately they had got steels in that condition in a very delicate state of balance with the result that it was not always possible to predict precisely what would happen. One did not know precisely how much retained austenite was there. One did not know the extent to which it would grow or shrink, when the temperature was either raised to the boiling point of water or oil ; or, again, when deep-freezing took place. But, arising out of all that, there was an important feature of the deep-freezing process. The decomposition of austenite into martensite in hardening caused alteration in size. If you had any austenite retained you incurred a further alteration in size, either with time or with temperature, as

the remaining small quantity of austenite decomposed. If you introduced a process such as the deepfreezing process, which eliminated that remaining austenite as completely as was possible at the moment, then you had largely eliminated the reason for size alteration at later stages. You had stabilised the gauge tool dimension much more than you would have been able to do in a short time before.

Mr. ELSON said there was one more interesting point arising out of that, namely, that the sudden change of 17/10 to which he referred seemed to create an unbalanced condition in that from that point they started to get shrinkage. The conclusion they reached was that the martensite causing shrinkage and the retained austenite causing growth were more or less balancing, and in order to eliminate those they had to get the same balance in tempering.

Mr. CRAIG MACDONALD replying said that appeared to be a very reasonable supposition. It was obviously unsatisfactory from the point of view of estimating the controlling dimensions that you should have two warring factors in the steel—one tending to cause shrinkage and the other tending to cause expansion—because a state of balance in those circumstances, with modification of temperature throwing weight either to one side or the other, left you with a sense of instability which could be extremely disturbing and which did cause a good deal of trouble. It had to be borne in mind that if the part was going to be hard, you would always have a considerable amount of untempered martensite. He suggested that once any retained austenite had been removed and only untempered martensite was left to be dealt with, you could expose the part for a long period to the highest temperature you thought fit consistent with the retention of adequate hardness. By so doing you would temper the martensite as far as one dared do and retain the hardness needed, and would have gone a long way to stabilise it from that point of view. If you were still left with some instability, that may not be due either to austenite or martensite but to stress effects in the steel, depending upon the method of heat treatment, shape of part, tool or gauge, and so on. Those could make themselves evident over a long period, the stress relieving itself slowly with time. That was one factor which had to be taken into consideration, because stresses in fully hardened or partially tempered parts could be very substantial indeed. Sometimes stress in steel could be made so high as to affect the life of the component considerably. If it were the wrong type of stress it would reduce the life of the component. If it were the right type of stress it could give a considerable improvement in the life of the component.

Mr. RANDALL said he had rather a difficult problem with the disc harrow used on agricultural machinery. The disc was of about 20-in. diameter, gauge about 2 in. 8 thou. plane. He had contem-

plated heat treating this right through and wondered if the author could recommend any type of plant.

Mr. MACDONALD regretted that he could not attempt to answer that question satisfactory on the spot, because there was so much information he would require arising out of the firm's experience with those parts. Also he would find it very difficult to recommend equipment without directing Mr. Randall's attention to certain proprietary types of furnaces, and it would be appreciated that that was not within his province at an Institute meeting.

Mr. MARSDEN said he had always understood that it was a fetish to demand small grain size in steel, and that it was not a particularly good feature. He thought Dr. Hadfield had told them that at one time. He had heard that the Americans gave people who demanded it the small grain by adding aluminium to it. He would like to know if grain size was so really important, or whether perhaps it was important in carbon steels and not alloy steels.

He would also like the author to tell them more about spheroidising. He believed that above a certain condition there was a sort of inside out effect with hardened carbons outside.

Mr. MACDONALD, in reply, said the question of grain size could not fairly be described as a fetish. Dr. Hadfield was a great fellow, but one of his favourite methods of getting information was to start a controversy, by making some highly controversial statement which he did not necessarily believe himself, and then stand back and listen to the discussion, walking away afterwards with the information he wanted ! He felt that that may have had some bearing in that particular case, because the grain size question was important from the point of view of engineering. The fine grain steels, for example, were much tougher and ductile, which was very important. It also affected the machinability very considerably, because that increased toughness reflected itself in the difficulty with which the fine grain steels were machined as compared with the coarse grain steels.

Whether you should specify a fine grain steel or a coarse grain steel was naturally dependent upon the over-riding features with which you were concerned. Design considerations might determine a fine grain steel, but if they were not strong you might, for machine shop reasons, decide to have coarse grain steel and the improved machinability arising from it.

Those were examples of the ways in which grain size specification could affect them, and they were a pointer to the extent to which they would affect them in the years to come. He had attempted to explain that a particular grain size, whether it be small or large, might have advantages depending upon the particular requirements.

As far as carbon and alloy steels were concerned, he thought he could go so far as to say that grain control was rather more important for the higher duty steels, i.e. the alloy steels, but to-day

advantage could be obtained for engineers by control of grain in carbon steels. The effect was very marked with alloy steels and he was a strong contender for grain size control in both.

As far as spheroidising was concerned, he thought he could deal with that fairly briefly. Cast iron had got a lot of free carbon in the form of graphite flakes, which were intermingled in the sort of pattern which made it impossible to cut through the piece of iron and avoid the graphite flakes. The distribution of carbides in the steel, although not free carbon like the carbon in cast iron, was something similar from the point of view of machinability. You could have carbide so distributed that you were cutting through it all the time. If you could, by a process of treatment, lump the carbide up so that instead of having a herring bone and feathery pattern distributed throughout the iron, you had got globules in a lake of iron, the prospect of the tool going through the pure iron matrix and its progress not being impeded by the herring bone carbides was very greatly improved. The carbides were harder by far than iron matrix, and the less the tool came into contact with them the longer it would live without regrinding.

Mr. MONK said that the author had mentioned in his paper the use of synthetic atmosphere for decarburization. They had been using tools for press work of 1 per cent. carbon, 0·5 per cent. chromium, and probably 0·25 per cent. anadium. Experiments carried out at constant temperature (this temperature specified by the manufacturers at somewhere about 60 degrees above critical point) gave evidence of distinct cracking. That cracking appeared to disappear when they repeated the experiments with ordinary atmosphere. When using synthetic atmosphere the iron wire used for holding those parts showed distinct signs of case hardening.

Mr. MACDONALD said the only comment he had to offer was that the particular synthetic atmosphere used in that instance appeared to have been unsuitable for the purpose. It had been said that the iron wire used for supporting parts was quite heavily carburized. It would appear, therefore, that the atmosphere was very high in carbon monoxide content. Any steel parts put in it at temperatures above 760°C. would carburize quite rapidly, and it was possible that the carburizing effect was notable on the tools as well as on the wires used to support them. Also the lack of homogeneity in material, due to increase in carbon content at the surface, might well, in a steel which was going to have very high internal stress, have produced those conditions in which crazy cracking on the surface appeared. A steel with 1 per cent. of carbon or thereabouts and a little alloy content was in a very highly stressed condition when it was hardened.

The alterations in volume which he mentioned were dependent upon composition, and if atmosphere was introduced which altered the composition of the surface, he thought it was reasonable to

assume that it might have been responsible for the cracking described.

With regard to the point that when ordinary atmosphere was admitted the cracking disappeared, the suggestion he had to make was that an atmosphere much more neutral was produced. While he had emphasised earlier that he had so far found it impossible to get real neutral salt, he did feel that atmospheres which were very nearly neutral and consistently so were fairly readily obtainable in muffles. Various methods were available for producing atmosphere which would not have a strong carburizing effect, such as a proper balance of carbon monoxide to carbon dioxide content, and a very substantial increase had taken place in the use of nitrogen by the decomposition of ammonia. He would point out, however, that his explanation was largely theoretical although based on the information given in the question.

Mr. MILLINGTON said in connection with press tools was it the author's opinion that nitriding could increase the life of press tools, particularly when used in conjunction with very abrasive materials ? Also if the tools were nitrided, would there be much distortion ?

Mr. MACDONALD, replying, said that nitrogen hardening steels were very costly. Nitrided surfaces were very hard and resistant to abrasion. Consideration would have to be given in the case of particular tools to cost first of all, and again to the precise type of service to which they were going to be submitted. If the effect of abrasion was the only consideration in the service life, he believed nitriding of the steel would definitely give about the best result obtainable, because if you did not introduce pounding effects the nitrided surface of the steel was just about as resistant to abrasion as any metallic surface of which they knew, other than tungsten carbide types.

With regard to the question as to whether or not the process would be liable to cause distortion, the answer was yes, but it would depend very considerably on the shape. If a part was symmetrical the distortion would not be necessarily serious. If you took a plain bar and treated it on one side so that it would not be nitrided and left the other side exposed to nitriding atmosphere, the bar would be very considerably bent, because in the nitriding process the surface grew something in the order of one thou. per inch. You did not, of course, get the full effect of that, because some was locked up in stress, but that was the root cause of the distortion to which he had referred. The shape of the tool would determine whether or not the distortion, in those circumstances, was going to be too serious to make it a practicable proposition ; because one had to remember that you could not always rectify distortion if rectification was going

to necessitate the removal of a portion of the nitrided surface. In non-symmetrical parts the danger of very considerable and serious distortion was there if they were going to be nitrided.

Mr. MYER then proposed a vote of thanks to the author which was carried with acclamation, and the meeting then terminated.

ATOMIC ENERGY

by H. PEARSON, B.A., Oxon.

Paper presented to Derby Sub-Section, November 19th, 1945.

Most of you will have guessed that I am not going to speak about the atomic bomb, since in the first place I know little about it, and in the second place there are still official secrecy acts in operation. Nevertheless, under the screen of the above title, I thought that a lecture on modern atomic physics would be particularly appropriate at the present time and I hope may serve to help us to sort out the " wheat from the chaff " in the information at present appearing in the newspapers. I left this subject late in 1935, but was aware in 1939 that the basic reaction for an atomic bomb had been discovered. The work since then is completely secret, but I hope to trace out the development of atomic theory from its origin to the stage of the beginning of this atomic bomb.

The title " Atomic Bomb " is a complete misnomer, since all existing bombs are atomic. That is, energy is suddenly released from chemical reactions which proceed by virtue of energy interchanges between atoms. The point of this particular bomb is that energy is being obtained from the atomic nucleus, so that the proper title should be Nuclear Bomb, and it is in particular with Nuclear Physics that I shall deal.

Beginning of Atomic Theory.

It is the prerogative of the Ancient Greeks to have thought of everything, even including the Gas Turbine and Jet Propulsion. Just the same they thought up an atomic theory, and the atomic constitution of matter was frequently employed by Newton. Yet the introduction of a thorough-going Atomic Theory in Chemistry belongs to John Dalton in 1801 or 1802.

Dalton considered that all elements were made up of a large number of ultimate particles or atoms which preserved their individuality in all chemical change, and he regarded the atom as indivisible. The atoms of all the different elements were quite distinct, in particular as regards mass. To satisfy the demands of chemistry, it is now necessary to assume that there are about 92 different atoms, though if one takes into account all the different varieties that are now known to exist, the number is legion. To anyone who is a general believer in the principle of scientific economy of hypothesis the atomic theory is scarcely attractive, but nevertheless it has had tremendous success in explaining the reactions of chemistry.

Development of Atomic Theory.

The first hint of any relation between the various atoms came from Newlands in 1863, who noticed that if the elements were arranged in order of increasing atomic weight, then the various properties, both physical and chemical, seemed to re-appear periodically every 8th element, so he called his discovery the Law of Octaves. There were many exceptions and faults in this law, but the general periodicity was noticeable. His communication was received with coolness by the London Chemical Society, who replied that if he tried arranging the elements in alphabetical order he would probably have just as much success.

Nevertheless, six years later Mendeleef published his celebrated Periodic Law and System of the elements, which was a more accurate statement of the same thing. Table I shows this periodic system, which is a modern version of his system. It will be observed that Hydrogen, the lightest atom, is all on its own, followed by Helium, four times as heavy, an inert gas having, we may say, no chemical properties at all ; Lithium, etc. ; and then returning to Neon, another inert gas, etc.

It is important to notice that the arrangement is not quite in order of increasing atomic weight (Argon and Potassium for instance). This is a point of some importance. In this arrangement all the elements in columns have the same sort of properties, the intensity of such properties varying as we proceed down the column. Along the rows the various properties change from inert gas to strongly electropositive, changing gradually to strongly electronegative.

This table is exceedingly instructive. The point for our purpose is that by 1869, it was realised that atoms might have some structure because of these recurrences of properties as the mass of the atom increased.

Discovery of the Electron.

In 1897, a metaphorical bomb hit the world of physics. T. J. Thompson discovered the existence of ultimate particles of electricity, the negatively charged electron, and henceforward it appeared that electricity as well as matter had an atomic structure. Almost immediately afterwards, the positive particles necessary to preserve the electrical balance were discovered. It was found that the charges of the two particles were equal and opposite, but whereas the positive particles had masses just the same as that of the atoms from which they came, the electrons only had a mass of approximately 1/1860 that of the lightest atom—Hydrogen.

It was evident that the positive particles were atoms which had lost an electron, consequently the electron was one of the constituents of the atom, and moreover, it looked as if all matter was going to be electrical in origin.

Structure of the Atom.

In 1911, Rutherford published his picture of the structure of the atom, and in 1913 Niels Bohr (of whom you have just read in the newspapers) elaborated the theory and made calculations for the Hydrogen atom which explained the whole complicated subject of the so-called spectrograph of the element. The atom is to be looked on as a central positively charged nucleus having extremely small size, even in comparison with the atom, but containing nearly all the mass, with electrons moving round this nucleus in orbits ; rather, in fact, like the solar system. The Hydrogen atom, for instance, is just a nucleus with one positive charge and one electron moving round it ; the Helium atom has a nucleus of four times this mass but only twice the charge, with two electrons moving round it. At the other end of the scale, Uranium has a nucleus of 238 times, with a charge of only 92 times that of Hydrogen, and in consequence 92 electrons moving round it in orbits.

The configuration of the orbits adopted by these electrons is extremely complex, but it was soon found that only definite orbits could be taken up and the number of electrons in each particular orbit was fixed. Thus the first orbit, nearest the atom, could be occupied by only two electrons, the next one by eight and so on. The electrons nearest the nucleus were naturally the ones most strongly attached. It is the number of electrons in the outermost orbit that determine the main chemical nature of an atom. If the outer orbit of the atom has just the right number of electrons, then the arrangement is very stable and the atom is not prone either to accept or give up an electron. Such a substance is chemically inert, as for instance the inert gases, Helium with a full complement of two electrons in the first orbit, Neon, with two in the first and eight in the second, etc.

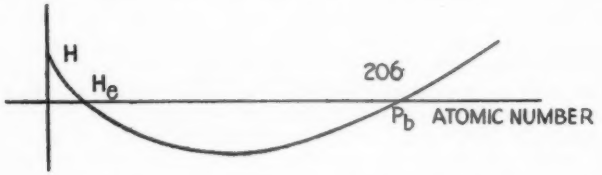
In general, however, the number of electrons is always a little more or less than will fill up complete orbits. It is these spare electrons in the outer orbit which determine the chemical nature of the atom. If there is just one electron left over in the outermost orbit, it will be prone to be easily lost and the atom is said to be electropositive ; if, on the other hand, there is just one short in the outer orbit, it will be prone to accept another readily and the atom is said to be electronegative. When the two types of atoms are brought into proximity under the right conditions, the result is the birth of a stable substance, a compound of the two elements.

It will be seen, therefore, that the numbers of electrons in the various orbits is just the periodicity which Mendeleef observed in his periodic table. There is just this difference, that it is now the charge on the nucleus that governs the chemical properties, and not mass, and that is why in one or two cases the mass increase is anomalous.

To remove the electrons from their orbits requires quite a large

amount of energy. When the electrons return, this energy is given up again. For orbits remote from the nucleus the job is not so difficult, and the result of the electron returning is that the energy is given up, as say, red light. For orbits nearer the nucleus we get blue light, or ultra violet, or in the limit the hard X-rays. To excite X-rays is therefore quite difficult, and to do it the atoms of a heavy element have to be bombarded with electrons in a high vacuum tube under a field of many thousands of volts.

This is, therefore, the picture of the atom that we had till, say, the end of the last war. Practically nothing was known of the nucleus, but some speculations had been made. It was realised that just as the electron was an ultimate particle, so was the nucleus of Hydrogen, usually called a proton, and it seemed that the nucleus must be made up of these two particles. Thus the Helium nucleus was made up of four protons and two electrons giving a resultant mass of 4 but only a charge of 2, and similarly for the other atoms. A remarkable thing was now found, that if the weight of the atoms constructed in this way was compared with the known weight, there was a discrepancy. If this discrepancy was plotted against atomic charge or number as it is known we get a picture :—



showing a deficit for all the elements up to Lead, and a surplus for those above Lead. It was known by this time that energy and mass were one and the same thing ; it was evident, therefore, that the elements below Lead were all formed with evolution of energy, and were therefore stable, while those above Lead were formed with absorption of energy and were therefore unstable. This instability had already been found for these elements, and was known as Radioactivity. Now if Hydrogen could be induced to form atoms at the trough of this picture, or heavy atoms like Uranium to break up into two equal parts or so, then the resultant energy efflux would be terrific. As a matter of fact, the Uranium was breaking up but, as will be seen, very slowly, and in any case only descending in small steps down the table as far as Lead, while nobody as far as I know has had much luck in synthesizing elements from Hydrogen.

Even if the above process could be done, it does not represent the greatest energy yield that can be obtained in an Atomic Bomb. If matter could be completely eliminated and turned to energy, the

yield would make the present bomb appear an extremely puny thing. The reaction of a proton and an electron bursting into a flash of energy has never yet been observed however, and I have a strong feeling that it will be very difficult to accomplish.

I ought to mention here that it is no longer believed that electrons exist in the nucleus, so that this picture is somewhat erroneous. Nevertheless in effect the picture is correct.

Isotopes.

Again working on the previous basis that all nuclei of atoms are made up of protons and electrons, it will be seen that if we take any nucleus you like and add one proton and one electron to it, the result will be that the charge on the nucleus will remain the same and therefore all the chemical properties will be identical, but the mass will be greater. Consequently we have a different substance, yet one possessing the same chemical properties as the original, and the two substances are called Isotopes.

The existence of large numbers of such isotopes is now well established. In particular I would draw your attention to the Periodic Table, and it will be seen that Chlorine has an atomic weight of nearly 35½. This is because it is almost an equal mixture of two isotopes, 35 and 37. Uranium 238 has about 1% of its weight made up of an isotope 235, of which more later, and another at 234. But all the elements have a number of isotopes, many of which never existed at all, but have recently been synthesized.

I am sure that at this juncture you would wish me to say something about possibly the most famous of these isotopes—Heavy Hydrogen. The existence of an isotope of Hydrogen having a mass double that of normal Hydrogen, but of course the same charge, had been suspected for some time, but it was eventually discovered that in an alkali plant the water from an electrolysing plant that had been in operation for some time was appreciably denser than normal water. From this, 1 cc. of 90% pure Heavy Hydrogen was separated. This is chemically indistinguishable from Hydrogen but is twice as dense.

Heavy water, instead of consisting of atoms of oxygen attached to two hydrogen atoms, consists of either

$$O\begin{matrix}H\\D\end{matrix} \qquad \text{or} \qquad O\begin{matrix}D\\D\end{matrix}$$

Heavy Hydrogen nuclei or Deutrons are extremely useful in atomic research, and are a very effective source of particles called neutrons, essential for the purpose of the Atomic Bomb. The Germans captured the main source of Heavy Hydrogen in Norway, and this is why it was attacked many times by us.

Radioactivity.

I now wish to return to 1896, when H. Bequerel discovered Radioactivity. He noticed that compounds of Uranium had the property of " fogging " a photographic plate, and of rendering the surrounding air conductive to electricity. The rays were extremely penetrating. By these methods of detection, Thorium was discovered in 1896 and Actinium in 1899. All these substances appeared to be giving out rays which had the property of fogging a photographic plate, knocking an electron off a gas atom, and penetrating quite a thickness of lead.

This was considered quite a minor phenomenon until Mme. Curie isolated a trace of material from the ore pitchblende, which had an activity many thousands more than that of Uranium. This was Radium, and at the same time she found Polonium, another radioactive element of less intensity.

After this, work proceeded at great pace, and it was established that the radioactive elements were actually in process of breaking up and as they did so giving off rays of three sorts :—

α rays positively charged particles, found to be Helium nuclei

β rays which were electrons.

γ rays very hard X-Rays capable of passing through up to 7 cm. of aluminium.

Table II shows the radioactive series and the manner in which the atoms break up.. Uranium breaks up by emitting an γ particle and becomes Ur X_1, then successively gives off β rays, arriving back at an isotope of Uranium again. This breaks down into Ionium, which breaks down into Radium. By a series of steps, Radium eventually yields Lead, and the radioactivity comes to a complete stop.

It will be observed that these reactions take a considerable time in all though some of the products live only a short time. This quantity of Uranium will be half changed into Ur X_1 in 4590 million years, while Ur X_2 lasts only 1·14 mins, and the Radium C′ one-millionth of a second. You will realise that the experimental detection of all these changes represents a terrific achievement.

There are two important points to notice about radioactivity. Firstly we are witnessing the automatic break-up of heavy atomic nuclei with the production of very large quantities of energy, considering the slow rate of break up. If this rate of break up could be increased, an important source of power would become available, since Uranium is a relatively common element.

The second point is that the rate of break up of these elements is absolutely independent of all physical or chemical conditions, from the lowest temperature of liquid hydrogen to the intensest heat

existing. Nothing that physicists could do seemed able to affect the rate of these reactions, and thus the door seemed locked on this important source of power.

There are two other radioactive series of elements involving Thorium and Actinium, but they are of same the type as the above, and both end in Lead.

Rutherford's Artificial Radioactivity—1919.

We have seen that to knock one of the orbital electrons out of the atom requires quite a large amount of energy. Even the intensest beam of electron only sufficed to eject electrons, and could never come near enough to the nucleus to do any damage, because they were always repelled by the barrier of electrons. If a positive particle were used, the surrounding electrons would actually help the particle along and there would be a good chance of hitting the nucleus and literally breaking the thing up. Now to get the required velocity to do any damage, these particles had to be accelerated by a potential of millions of volts, and you didn't find this sort of thing in a Physics Laboratory in 1919. In this respect Radium was a godsend, because it was continuously emitting Helium nuclei at incredible speeds, and Rutherford used these particles to bombard Nitrogen. He found that Nitrogen absorbed the Helium atom and then broke up into two particles, one of which he identified as a Proton (Hydrogen nuclei). For instance :—

$$N_7^{14} + He_2^4 = H_1^1 + O_8^{17}$$

an isotope of Oxygen being formed. This was the first transformation of an element by artificial means, but it was on a scale infinitesimally small, and the energy necessary to set it going was nearly as much as came out of it.

Nevertheless, it marked an important step forward. Later it was established that all the light elements from Boron to Potassium (with the exception of Carbon and Oxygen) behaved in a similar manner.

The Fundamental Particles.

Unfortunately the simple picture of the Universe as made up of protons and electrons has vanished overnight, and although we have not yet had to resort to 92 different fundamental particles, the number has nevertheless departed from the alleged state of connubial bliss and quite a large family has resulted.

1. **The Electron.**

The first particle to be discovered and is negatively charged. Mass $8{\cdot}8 \times 10^{-28}$ grms. that is, there are $2{\cdot}4 \times 10^{26}$ in one grm., or if we accept the English billion of one million million, there are 240 billion billion electrons in one gramme. The charge associated

with an electron is very small ; in fact, to obtain a current of 1 ampere in a wire it is necessary that 7×10^{18}, or 7 million million million, pass per second, and this is what actually occurs when you switch on a current of electricity in a wire, for it is only the electrons which are mobile enough to flow through the wire.

We have seen that electrons form the outer shell of the atom and determine the ordinary properties of matter as we know it. It is no longer considered that they exist in the actual nucleus, and consequently other sorts of particles must exist to avoid the mass and atomic number being identical.

2. **The Proton.**

This is the nucleus of a hydrogen atom and has an equal charge to the electron, but of opposite polarity. It is however, about 1,860 times as heavy as the electron, and is considered to be a unit from which the other atomic nuclei are built up.

As a subsidiary however, there is the γ particle or Helium nucleus, which although built up from protons and some other particle is undoubtedly an extremely stable body, and there seems little doubt that it is this multiple unit that forms the main bulk of atomic nuclei, with some extra particles as binding matter.

3. **The Neutrino.**

This is little more than a term in an equation. Its properties are by definition almost non-existent. It is supposed to have about the same mass as an electron, no charge, but carries away large amounts of energy. Such a particle would have terrific penetrative power (greater than 140 kms. of air) and is therefore not detectable. One feels that it is little more than a ruse to help us out of some rather fundamental difficulties.

4. **The Mesotron or Meson.**

This is almost as vague a particle as the neutrino. I believe it is supposed to be almost 100 times the mass of the electron, and was predicted by a Japanese gentleman as the binding material in the nucleus between protons and neutrons. It is unstable when free, giving rise to extremely intense radiation. There is some effort at the moment to prepare this by bombardment, but voltages of the order of 100×10^6 volts will be necessary.

5. **The Position or Positive Electron.**

One always felt that the duality of proton and electron was a rather poor affair, a wife having a husband 1,860 times as heavy as herself being a poor sort of joke. This has been partially set right by the discovery of positive electrons, which appear to have about the same mass and charge as an electron, but of opposite polarity.

They are extremely unstable particles and are not considered to

be of such as a decent nucleus should build his house. They last such a short time that it is difficult to measure any of their properties adequately, but one day they may be of greater importance than the present atomic bomb, for if a positive electron finds a normal electron the two go off in a flash of radiation, which is pure energy. Consequently 1 grm. of positive and negative electrons could be made to go off and would produce 1,000 h.p. of heat for approximately 2/5 million hrs. As engines are only about 25% efficient, we should get 1,000 b.h.p. in an aero engine for approximately 100,000 hrs., or 77 years.

I feel that the question of large consumption of fuel that is held against our present jet engines would become a minor feature. Unfortunately, although this reaction certainly proceeds all right and no doubt could be controlled, it needs even more energy to produce the positive electrons, since they appear to be mainly formed by the inverse process of condensation from radiation. However, one never knows; I think it quite likely that this mechanism may form a future atomic bomb, but it most certainly is not the mechanism of the present one.

6. **The Neutron.**

From the point of view of atomic bombs, the most important particle. It was really discovered by the daughter of Mme. Curie, but not recognised by her, some 10-15 years ago. It was found to be emitted from certain light elements notably Beryllium when bombarded by $-\gamma$ particles from a Radium source.

It has a mass almost identical with a proton, but no charge. Consequently it has terrific penetrative power (ca kilometres in air), but when it does hit up against a nucleus fair and square a great deal of damage ensues. It is a difficult particle to recognise, except by its effects on such a nuclei. It is the trigger for the Atomic Bomb.

It is considered to be a main building block of atomic nuclei; these consisting of protons, γ particles and neutrons. An γ particle is supposed to consist of two protons and two neutrons. It is evident that an atomic nucleus therefore has a total number of protons equal to the atomic number and a total number of neutrons equal to (atomic mass — atomic number).

Artificial Radioactivity.

A disease now swept the physics world and the idea was to bombard any element you could think of (or lay your hands on) with any particle you could. We have seen that electrons are not much use, but there were γ particles of huge energy ready to hand, and very sensitive apparatus for detection of any effects. There were also neutrons, and bombardment was also tried with the nuclei

of Hydrogen, Heavy Hydrogen, and so on. The latter did not, however, exist with large energies, so it was necessary to accelerate them through a large electric field. Consequently there was a rush to put up large high voltage plants of millions of volts, and actually a stream of one milliamp of protons has been obtained under this voltage. The prime effort in this direction comes from America however, where Lawrence built the first cyclotron. This consists of a high frequency generator of a few thousand volts alternately applied to the particles, which are made to rotate in circles by means of a powerful magnetic field. The period is made to synchronize, and by keeping the particles continuously rotating the energy can be built up to a colossal extent. So immediately prior to the war there was a great rush to set up cyclotrons in nearly all countries.

Since there are 92 elements (not counting the many isotopes), and about 6 or so quite suitable streams of γ particles to bombard them with, you will see that there was work for everyone, and much too much for me to describe adequately.

There were roughly two types of artificial radioactivity obtained as a result of all these experiments. The first type was obtained by bombarding with γ particles and, apart from producing neutrons, the remainder was found to be radioactive and to disintegrate with a decor period but emitting positive electrons. The effect was confined to light elements. As an example, Aluminium :—

$$Al_{13}^{27} + He_2^4 = P_{15}^{30} + n_0^1$$

This is an isotope of Phosphorus and is radioactive :—

$$P_{15}^{20} = Si_{14}^{30} + e+$$

Thus a general artificial radioactivity had been generated.

The second form of radioactivity was obtained by bombarding with neutrons, by an Italian, Fermi. With the light elements the neutrons entered the nucleus and ejected an γ particle or a proton, for instance, for Aluminium :—

$$Al_{13}^{27} + n_0^1 = Na_{11}^{24} + He_2^4$$

This was a new isotope of Sodium and was a radioactive element, giving off normal electrons :—

$$Na_{11}^{24} = Mg_{12}^{24} + e-$$

and

$$Al_{13}^{27} + n_0^1 = Mg_{12}^{27} + H_1^1$$

$$Mg_{12}^{27} = Al_{13}^{27} + e-$$

arriving back, apparently, where we started.

With the heavy elements, the neutron was simply absorbed :—

$$I_{53}^{127} + n_0^1 = L_{53}^{128} + Xe_{54}^{128} + e-$$

and for this effect, the slower the neutrons the better.

Apart from obtaining radioactive products many transmutations of elements without subsequent radioactivity were obtained.

Mention has already been made of the early transformation obtained by Rutherford, and these have since been confirmed in all elements from Boron to Potassium (minus C & O).

By artificial acceleration, transformations were obtained with protons (Corkcroft and Walton). For instance, Lithium :—

$$Li_3^7 + H_1^1 = Be_4^8 = He_2^4 + He_4^4 \text{ (two alpha particles)}$$
$$Li_3^6 + H_1^1 = Be_4^7 = He_2^3 = He_2^4$$

the second reaction giving an isotope of Helium. With Boron, three Helium nuclei were obtained :—

$$B_5'' + H_1^1 = C_6^{12} = Be_4^8 + He_2^4 = 3 \times he_2^4$$

By this type of experiment transformations have been produced as well in Beryllium, Carbon, Flurine and Aluminium.

Beryllium is of special interest, a nucleus of Heavy Hydrogen being formed :—

$$Be_4^9 + H_1^1 + B_5^{10} = Be_4^8 + H_1^2$$

i.e. 2α particles and one deutron.

If Heavy Hydrogen nuclei are used for bombardment, a much wider range of transformation is available, and the system breaks up in all the possible ways consistent with the conservation of charge, mass and energy. Thus Boron bombarded by deutrons breaks up in eight different ways.

The case of Heavy Hydrogen bombarded by deutrons is of interest :—

$$H_1^2 + H_1^2 = He_2^4 = H_1^1 + H_1^3$$
$$= H_2^3 + n_1^0$$

the ultra Heavy Hydrogen appearing in one reaction, and the isotope of Helium in the second. The second reaction is a very efficient method of producing an intense source of neutrons, and I suspect was why we were so anxious to deprive the Germans of Heavy Hydrogen.

Transformations over the whole range of elements have now been obtained using artificial acceleration, principally by the cyclotron.

Neutrons have also provided transformations without resultant radioactivity, and even Oxygen has been broken up (cannot be so by α or H_1^1 particles

$$\left.\begin{array}{rl} O_8^{16} + n_0^1 = C_6^{13} + He_2^4 & \\ \text{and} \quad N_7^{14} + n_0^1 = B_5'' + He_2^4 & \text{The general result being the production} \\ C_6^{12} + n_0^1 = Be_4^9 + He_2^4 & \text{of an } \alpha \text{ particle.} \end{array}\right\}$$

The Atomic Bomb.

The tale of these transformations will undoubtedly have left a hazy and topsy-turvy picture in your mind, and this is quite correct, for it was the way of things in 1936–39. Results were being published every week, everyone was splitting nuclei in all

sorts of ways, for no rhyme or reason, and certainly with no ulterior motive in view like the Atomic Bomb.

Even so it appears strange to me now that we did not concentrate rather more on the heavy radioactive elements. They had the most energy, were in any case unstable, and good results may have been expected. Nevertheless, in all the reactions so far investigated there was never one which looked like propagating itself; that is, one which produced, on break up, a particle similar to the one that had broken it up. Yet this awe-inspiring result was achieved late in 1938, and even then set the whole scientific world reeling, as the awful possibilities revealed themselves.

It was discovered that Uranium, when bombarded with neutrons, broke up into two almost equal parts (the first time such a complete fissure had taken place in a heavy element) with the production of a number of further neutrons (3, I believe). These neutrons were themselves able to bombard other Uranium atoms and cause further explosion. In general, the chance of these collisions was very small and at the time the reaction could not be made to proceed because the neutrons always seemed to escape from the system before exploding a further atom. Measurements of the average chance of a collision between a neutron and a Uranium nucleus showed that to ensure that the neutrons could not escape a block of Uranium about a yard cube would be required. If this did go up, nobody on earth would be left to tell the tale.

It was then discovered that the reaction proceeded in a different manner with the two isotopes of Uranium 238 and 235. The 238 could be "fissured" only with high energy neutrons, while 235 could be "fissured" by both high and low energy neutrons. Furthermore, the reaction with Uranium 238 was complicated in that neutrons of intermediate energy could be captured without subsequent breakage. The result of all this was that the presence of Uranium 238 considerably "dampened down" the reaction, and if the 235 isotope could be separated out, there would be a much greater chance of the reaction proceeding on its own. In this case the amount of energy set free would be terrific and a real "atomic" bomb would result.

Nobody prior to the war considered that separation of these isotopes was possible on any practical scale. Nier, in America, had prepared a sample of Uranium in which the 235 was "richened up" by separation in a Mass-Spectrograph, but this method was laborious and consumed much more energy than would result from the bomb. In the first year of the war, however, a small group of men demonstrated that separation of the isotope was possible by gaseous diffusion. The Uranium was turned into a gas, possibly uranium hexa-fluoride, and diffused through porous containers, the lighter isotope diffusing slightly faster. The difficulties of this

process must have been tremendous, since there is only 1% difference in the masses of the atoms, nevertheless they were able to convince the British Government that the bomb was now a practical proposition. It should be realised that the whole job in making the bomb consists of the separation of the isotope.

As soon as it was realised that Britain was seriously starting on the Atomic Bomb, the American Government became interested and it was decided to transfer the work there, and the colossal sum of money spent on it is an indication of the vastness of the isotope separation job.

Meanwhile calculations had been made to show the minimum size of Uranium 235 that would "explode." It was then necessary to segregate the isotope in amounts smaller than this. By bringing together two hemispheres of material, each on its own quite stable, the critical size could be obtained, and one neutron would be sufficient to set off the bomb. Whether this is always available in our atmosphere, or whether a neutron source has to be carried in the bomb is a small matter, and one easily arranged for.

Considerable care has therefore to be taken in piling up Uranium 235, and if ever nature should have cared to try it, the result would have become cataclysmic. It suggests itself as a possible origin of the heat in the sun, etc.

There is one important question: How does this colossal energy manifest itself? It can only do so in two ways, firstly by imparting kinetic energy to the fissured fragments of the atom, and secondly by emitting radiation, and this is what happens. The particles in the lump of Uranium suddenly acquire terrific velocities and the result is to heat up the material to millions of degrees and generate enormous pressures. The lump expands with terrific rapidity and the result is an explosion.

Now it is obvious that some bits of the lump will be blown away before they have had time to catch a neutron. This is the reason that fast neutrons have to be employed to obtain the maximum reaction speed. Even so, the efficiency of the process is still low, and the major part of the bomb material scattered over Japan must still be Uranium 235, but in such a diffused state as to be quite harmless.

Mention has been made of the fact that Uranium 238 can absorb neutrons without subsequent fissure. The first result of this is the formation of a new Uranium isotope 239, which then gives off two electrons in steps, forming in this manner, two new elements of higher atomic number :—

$$1\ \text{Neptunium}\ {}^{239}_{93}\ \text{and}\ 2\ \text{Plutonium}\ {}^{239}_{94}$$

These are known as Trans-uranium elements and do not occur in nature. Plutonium is of special interest in that it undergoes fissure

apart to be safe. As the size of the bomb increases the two sections quite readily in a similar manner to Uranium 235. Moreover it can be separated from Uranium by simple chemical means. Here then is the possibility of another type of bomb. Uranium 238 can be bombarded by an intense source of neutrons being surrounded by heavy hydrogen to slow the neutrons down to the correct velocity. In this way Plutonium can be formed and later separated chemically. A bomb can then be made of this as before. It is possibly on these lines that the Germans were working, for it is doubtful if they had the courage to tackle the isotope separation method.

The Plutonium reaction is of interest, for it can be fissured by very slow neutrons and is ideal for a continuous steady reaction to provide energy for commercial use. There is no doubt that a large amount of work is going on with this element at the present moment, directed towards this end.

There are obviously many problems to be solved before atomic energy can be used in the service of man, but I do not believe it will be many years before aircraft, for instance, no longer have to carry enormous fuel loads, and the problem of building long distance aircraft will have been solved. Probably by then nobody will want them.

DISCUSSION.

MR. JENNINGS: I would like to know whether Mr. Pearson's attention has been drawn to an article in the Sunday Press, in which some inventor claims to be able to drive a car by using Uranium atoms with liquid air to split distilled water to Oxygen and Hydrogen, passing these gases into the normal induction chamber.

MR. PEARSON: It is strange that not until after the discovery of Uranium and the Atomic Bomb did we hear anything about the possibility of driving motor cars by this method. I should warn you not to place too much importance upon it at the present time. The main thing is that the energy associated with the nucleus is very large, and it is difficult to get at this energy in the first place without producing greater forces than are available in the ordinary chemical laboratory. The energy contained by liquid air would appear to be insufficient to start such a reaction.

MR. ELLIOTT: I would like to ask one simple question. How far apart do the two halves of the Atomic Bomb have to be kept in order that they do not react upon the other? Do they have to be dropped in two separate projectiles or are they combined in one?

MR. PEARSON: It rather depends upon how big you make the bomb, though it is not true that there is only one size. If you make the bomb about the smallest size possible, though still big enough to explode, you need keep the two halves only the smallest distance

have to be kept further away, it is just a question of size. I would point out that the bombs at the present time are only about 1% efficient, since a large number of the atoms are dispersed before they have had a chance of being broken up. It will follow, therefore, that the two parts have to be put together with the greatest possible speed, and mechanical methods are not really satisfactory since the bomb blows up too soon. The latest tendency is to blow the two parts together by an explosive charge contained in the case, and by this means you get a more effective bomb than you would normally. The two bombs dropped on Japan were different only in that the mechanism was different. It is probable that in the first bomb the two halves were driven together mechanically, while an explosive was used in the second bomb.

MR. BRANFIELD: I would like to know the source of atomic energy. The lecture has been intensely interesting. When the lecturer referred to Prof. Joliot and Mme. Curie-Joliot's discovery that by bombarding Beryllium with alpha particles, a proton was released and an unstable isotope of Nitrogen was formed, I desired to remind him that the final product of the experiment was that the unstable Nitrogen had only a short life, and fell to Carbon. Now Carbon is the primary organic element; if this element can be produced by any means, at will, we can surely produce any element from any other, by selective bombardment.

Our lecturer said that Uranium had a half life of one thousand million years. That is not very long in the history of the earth. I cannot help but think that Uranium is being built up somewhere now, in nature. There was an interesting discovery in Russia; the water from certain oil fields was rich in radium and I read as far back as 1934, that radium had been discovered, also in Russia, in the growing point or tip of wheat. I have never seen any further reference to that, but it has been definitely found by the late Hugh Ramage of Norwich, that the growing point of wheat is radioactive or unstable Rubidium, which disintegrates in the stem tissues to Potassium, releasing energy to the plant's growth.

MR. PEARSON: The point you are making about radioactivity of the alkali metals has been investigated over a long number of years, and it has been proved it is not radioactive at all. If it is radioactive, it is completely different from the ones we normally experience. As regards the "life-cycle" you refer to, I am afraid I cannot comment on it.

MR. CHANDLER: May I ask a very elementary question? Heavy Hydrogen and heavy water have been referred to. Is heavy water, such as is found in an electrolytic oxygen plant after prolonged use actually much heavier than ordinary water, and what is its approximate density?

MR. PEARSON: It is appreciably heavier. Ordinary water is $\frac{H}{H}O$

Heavy water can be of two sorts, i.e. $\frac{H}{D}O$ or $\frac{D}{D}O$

Consequently the density ratios will be roughly in the ratio of 18 : 19 : 20 for the three types. 100% heavy water is thus approximately 11% heavier than normal water.

MR. SHORT: May I congratulate Mr. Pearson on the way in which he has conducted his lecture in such a mixed audience. Most of us here are production engineers, but we have a lot of visitors tonight, and some are obviously chemists.

I only hope that Mr. Pearson will be able to come along in a few years time and tell us how we are going to receive this energy, and explain to us how we have got to put it into our factories.

I have very great pleasure in proposing a hearty vote of thanks to Mr. Pearson.

TABLE I.

PERIODIC SYSTEM OF THE ELEMENTS.

SERIES	GROUP 0.	GROUP I.	GROUP II.	GROUP III.	GROUP IV.	GROUP V.	GROUP VI.	GROUP VII.	
	—	R_2O	R_2O_2	R_2O_3	R_2O_4	R_2O_5	R_2O_6	R_2O_7	
	—	RH	RH_2	—	RH_4	RH_3	RH_2	RH	
1		H 1:008							
2	He 4·00	Li 6·94	Be 9·02	B 10·82	C 12·00	N 14·008	O 16·00	F 19·0	
3	Ne 20·2	Na 22·997	Mg 24·32	Al 26·97	Si 28·06	P 31·027	S 32·064	Cl 35·457	GROUP VIII.
4	A 39·91	K36·096	Ca 40·07	Sc 45·10	Ti 48·1	V 50·96	Cr 52·01	Mn 54·95	Fe 55·84 C°58·94 Ni 58·69
5		Cu 63·57	Zn 65·38	Ga 69·72	Ge 72·60	As 74·96	Se 79·2	Br 79·916	
6	Kr 82·92	Rb 85·44	Sr 87·63	Y 88·9	Zr 91	Nb 93·1	Mo 96·0	—	Ru101·7 Rh102·91 Pd 106·7
7		Ag 107·88	Cd 112·41	In 114·8	Sn 118·70	Sb 121·77	Te 127·5	I 126·932	
8	Xe 130·2	Ca132·81	Ba 137·37	La 138·9 and 13 other elements of rare earths.	Hf 178·6	Ta 181·5	W 184·0	—	Os 190·8 Ir 193·1 Pt 195·23
9		Au 197·2	Hg 200·6	Tl 204·39	Pb 207·20	Bi 209·00		—	
10	Rn 222	—	Ra 225·95	ac	Th 232·15	pa	U–1 238·17	—	

TABLE II.

Atomic Weight.	Atomic Number.	Average Life.	Isotope.	Symbol.	Uranium-Radium-Actinium Series	Symbol.	Isotope.	Average Life	Atomic Number.	Atomic Weight.	Thorium Series.	Symbol.		Isotope.	Average Life.	Atomic Number.	Atomic Weight.
238–18	92	$4{\cdot}59\times10^{9}$yrs	U	UI	Uranium I												
234	90	24–5 days	TH	UX_1	Uranium X_1												
234	91	1·14 mins.	Pa	UX_2	Uranium X_2 brevium.												
234	92	Ca 10^{6}yrs.	U	UII	Uranium II						Thorium	Th		Th	$1{\cdot}65\times10^{10}$yrs.	90	232·12
					Uranium Y	UY	TH		90	231	Mesothorium 1	MsTh	1	Ra	6·7 yrs.	88	228
					Proactinium	Pa	Pa	$1{\cdot}25\times10^{4}$yrs.	91	231	Mesothorium 2	MsTh	2	Ac	6·13 hours	89	228
					Actinium	Ac	Ac	13·4 yrs.	89	227							
230	90	$7{\cdot}6\times10^{4}$ yrs.	Th	Io	Ionium Radioactinium	Rd Ac	Th	18·9 days	90	227	Radiothorium	RdTh		Th	1·9 yrs.	90	228
226	88	1,600 yrs.	Ra	Ra	Radium Actinium X	AcX	Ra	11·2 days	88	223	Thorium X	ThX		Ra	3·64 days	88	224
222	86	3·82 days	Rn	Rn	Radon Actinium	An	Rn	3·92 secs.	86	219	Thoron	Tn		Rn	5·45 secs.	86	220
218	84	3·05 mins.	Po	RaA	Radium A Actinium A	AcA	Po	2×10^{-3} secs.	84	215	Thorium A	ThA		Po	0·145 secs.	84	216
214	82	26·8 mins.	Pb	RaB	Radium B Actinium B	AcB	Pb	36 mins.	82	211	Thorium B	ThB		Pb	10·6 hours	82	212
214	83	19·7 mins.	Bi	RaC	Radium C Actinium C	AcC	Bi	2·16 mins.	83	211	Thorium C	ThC		Bi	60·5 mins.	83	212
210	81	1·32 mins.	Tl	RaO	Radium C Actinium C″	AcC	Tl	4·76 mins.	81	207	Thorium C″	ThC″		Tl	3·2 mins.	81	208
214	84	10^{-6} secs.	Po	RaC	Radium C′						Thorium C′	ThC′		Po	10^{11} secs.	84	212
210	82	25 yrs.	Pb	RaD	Radium D						Thorium *ffi*	THffi		Pb	Stable	82	207·7
210	83	4,185 days	Bi	RaE	Radium E												
210	84	136·3 days	Pi	RaF (Po)	Radium F (Polonium)												
206	82	Stable	Pb	Raffi (Po)	Radium *ffi* (Lead)												
			Pb	Raffi	Radium*ffi*[β] (hypothet- Actinium*ffi* (hypothet-	Acffi	Pb	Stable	82	207	Thorium *ffi* (lead)	Thffi (Pb)		Pb	Stable	82	207·7

MEMORANDUM ON TECHNICAL EDUCATION

prepared by

THE EDUCATION COMMITTEE

of

THE INSTITUTION OF PRODUCTION ENGINEERS

Introduction.

The terms " Production Engineer " and " Production Engineering " are of comparatively recent origin. They emanated after the conclusion of the 1914-1918 War due to the prominent part which Engineering Production had played during that period.

In 1921 the Institution of Production Engineers was founded in order to create and establish a medium whereby Engineers responsible for production could meet and discuss their many problems.

It was soon realised that a more scientific approach to many of the problems with which they were faced was desirable, and the Board of Education was approached with a view to recognising these requirements, with some success.

During the second World War the Production Engineer has again played a vital part in ensuring final victory. It is felt that even more could have been accomplished had the desired facilities been available for the training of the Production Engineer during the past generation.

The considered views of this Institution in regard to this vital question are hereby submitted.

Collaboration between Education and Industry.

The new Education Act has done much to create a wider interest in education and training amongst all sections of the community. It is not enough, however, to create interest ; it must be maintained and, unless there is an organisation which will enable such maintenance to be effective, the full objective is unlikely to be attained.

Such an organisation should :—

(*a*) Create opportunity for all interested bodies to achieve continuous co-operation with local educational activities.

(*b*) Ensure that this continuous co-operation is carried through appropriate intermediaries to national bodies and thus provide an open channel for the transmission of policy and performance.

This memorandum has been prepared by a professional Institution which works almost wholly in the field of Industry. It is recognised that industry is one only of the many bodies which are

interested in educational matters, although its relative importance now and in the future cannot be over emphasised. To explain the views of the Institution regarding requirements of industry and its relation to education, suggestions are made which embody the formation of Educational Advisory Councils.

The general organisation would envisage three stages of co-operation, local, regional and national. The object desired is the establishment of a clear connection between those who deal with the individual at the local stage and those who decide the national educational policy. It seems probable that the intermediate, or regional stage would be found essential.

To commence with the Local Educational Advisory Council. It is proposed that the three main types of school envisaged by the Act should be represented. The other Members of the Council might be drawn from the Local Education Committee, the Parents' Association or some similar body, the local Juvenile Employment Officer of the Ministry of Labour, representatives of local industry, Trades Unions and the local Chamber of Commerce.

The suggested terms of reference for the Local Educational Advisory Committee are :—

(*a*) To promote understanding of the problems affecting industry and commerce as well as those of parents and teachers.

(*b*) To assist in meeting the requirements of the component Members.

(*c*) To bring before educational and other authorities in the area the requirements of the young persons.

(*d*) To encourage and give vocational guidance to all young persons about to enter another phase of development, either to higher education or to industrial and commercial life.

(*e*) To make suggestions with regard to the " County Colleges " or to corresponding organisations within the factories.

The connecting link between the local and national advisory councils would need to have a wider basis than that of the purely local council, hence a regional advisory council appears to be indicated. This regional council would draw representatives from the local advisory councils and thus ensure the co-operation necessary between the smaller units. Such a regional council would have similar terms of reference to those previously outlined with minor differences in representation. Representatives from parents' associations or ratepayers' associations are not required since their interests would be catered for in the local advisory councils. It is suggested that here is the appropriate stage for the inclusion of representatives from the larger technical colleges, universities and also from the various professional institutions.

At the final stage is found the National Educational Advisory

Council. The representation on this body would be similar to that on the regional council, the delegates being nominated by the regional councils but not necessarily entirely from their members.

The chairman of this national council should be the Minister of Education, or his deputy, and, it is suggested that a representative of the Trades Union Council be added, whilst the representation of the professional technical institutions should be limited to two elected members acting on behalf of all.

The National Educational Advisory Council would thus comprise the chairman—the Minister of Education—with representatives of primary, secondary and technical education; the universities, industry, commerce, Ministry of Labour, the professional technical institutions and the trades union councils.

It is claimed that the advantages of the proposals as outlined are as follows:—

1. Recognition that local enthusiasm and co-operation are essential.
2. Recognition that Industry is not the only body which absorbs the educated adolescent.
3. A balanced communal representation on each advisory council.
4. Opportunities for greater development of vocational guidance and selection.
5. Provision of opportunities and facilities for representatives of local industry to continue the co-operation which has been so useful in other directions during the war and which could now profitably be applied to educational problems.
6. An identical form of organisation would be carried through from the local to the highest national stage with no break in continuity either of out-look or action.
7. Possibilities of greater co-operation at various stages between the various professional institutions which would tend to broaden their individual outlooks and render their advisory roles more valuable.

Training of Teachers.

The greatest problem that will face the authorities in the expansion of classes for the purposes of technical education will be the provision of suitable teachers. The housing of the machines and apparatus necessary for training the Production Engineer does not require magnificent buildings; the efficiently trained teaching staffs are essential.

In technical colleges to-day, the work of teaching, on the engineering side, is mainly carried out by a relatively small number of full-time staff members together with a far larger number of specialist,

or other, teachers who are on a part-time basis, usually in the evenings only.

The problem of the teacher in a technical college is very different from that of his colleague in the elementary or secondary school. The students attend mainly of their own free choice. There is no compulsion, and the teacher holds his class together largely by his personality. He may know his subject thoroughly, but, unless he can hold the interest of his class by his method of presentation, inattention becomes obvious and eventually the numbers attending diminish. The fact that a person is a specialist in one subject and has a vast store of knowledge at his disposal, does not alone qualify him to teach that subject.

Reasons that have led to the change from active connection with engineering industry to the profession of full-time teaching are varied. Many, possibly too many, have entered technical teaching after obtaining an engineering degree and without adequate industrial experience, few of these have had any training in teaching methods while others have found their vocation through their experience in part-time teaching.

It is felt that the type of training in teaching which is given in the "colleges" for elementary school teachers is of little value to the teacher in technical institutions; conditions in the latter are widely different and methods must be adapted to the conditions.

It would appear that more conferences and summer schools, which were once a feature of the policy of the Board of Education to assist technical teachers, should be revived. During such courses or "conferences" teachers get together, compare methods, hear fresh ideas propounded and, above all, study methods of successful colleagues who give the lectures or lead the discussion grouds. Attendance at such courses should be made compulsory for new entrants to teaching in technical colleges and those who have taught for some time should be directed to them as "Refresher" courses. That there is a demand for such courses is evident from the fact that the numbers who desired to attend were always greatly in excess of the places available. The length of the course should be arranged to attract the part-time teacher who, in present circumstances, needs to attend during his annual holiday. It would, however, be preferable for industry to grant special leave from regular employment for such courses.

It is suggested that a far closer collaboration between industry and the teaching profession is essential. In many places the members of the staffs of the various technical colleges are welcome visitors to local works, and the management devotes much time to ensuring that the visitors see methods and processes of general and special interest. These facilities should be widely extended and, where practicable, a teacher should be permitted to become a temporary employee of the firm concerned.

All teachers, whether elementary, secondary or technical could with advantage be encouraged to earn their living in industry for at least two years before taking up a whole time teaching appointment.

The transfer from teaching to industry and from industry to teaching should be made easy. No financial loss or loss of status should be involved. It should be the general rule that all full-time teachers of Production Engineering should spend some time of each year, or at least in alternate years, in active industry; thus bringing their practical knowledge up to date. Conversely, part-time teachers could, with advantage, spend some time as assistants in the classes taken by full-time teachers, where they could observe the methods of their more "professional" colleagues.

Much advanced production training will be covered by day classes. Up to the minute knowledge of processes, administration, etc., must be imparted by people in actual practice. Therefore day time facilities for students must involve occasional release of specialists for teaching also men who will usually be holding responsible posts in industry. It is felt that, for afternoons especially, such men could be spared once or twice a week without serious harm to their particular departments. This would be the most valuable type of co-operation with industry.

Equipment of Technical Colleges.

The main question that affects the Institution is the provision of the special equipment which is essential to a live and intelligent course in production engineering.

Much of the equipment for the study of Mechanics, Physics, and elementary ideas of Electricity, in the earlier stages of the work, is common to almost all branches of engineering.

The provision of such equipment is almost a routine matter, and most technical colleges are adequately provided for in this respect. It is when the time for special equipment arrives that difficulties are experienced.

To train for Production Engineering, and this may be defined as the art of producing articles for sale with the minimum expenditure of capital, labour and material, a well equipped workshop is essential. Facilities must be provided for bench-work, and work with simple machine tools. These should be regarded as demonstrating fundamental principles. Such machine tools, *e.g.*, simple lathes, shapers, and possibly millers are relatively inexpensive and do not suffer so severely from obsolescence as do the more specialised machines.

For advanced courses elaborate modern tools are necessary which all too soon become out of date. Few, if any, local education authorities can face the necessary expenditure. It is therefore recommended that the more expensive basic equipment should be

provided by the State, although special machines might be loaned by the manufacturers. To the manufacturer there is some advantage to be gained in having students trained on and familiar with his machines and to him it is at least as useful as sending his machine to exhibitions or shows. It is felt that such loans should be encouraged where possible. At the same time the importance of college equipment being kept up to date cannot be overstressed and it is recommended that the State should make adequate arrangements with the manufacturers of Machine Tools for the installation of up-to-date equipment and for these to be periodically replaced before the question of obsolescence arises.

Metrological Equipment.

Since the basis of successful production engineering is accuracy in dimensions, it is essential that the colleges should have adequate equipment of this type. In some forms of production measuring apparatus is relatively simple, but when the limits are fine, expensive measuring equipment becomes essential. The action of the Ministry of Education in developing the policy of using technical colleges as "Test Houses" is welcomed and should be extended.

Apprenticeship Schemes.

The widening of the scope of engineering during the past few years has, together with an increase in quantity production somewhat tended to retard apprenticeship training. It required a second World War to make us alive to the fact that this lessening interest in the training of craftsmen was once again seriously handicapping the engineering industry, and to remind us that we had forgotten all too quickly the lessons of the First World War.

This lagging interest may be ascribed amongst other things to :—

1. The desire of youth, sometimes supported by family influence, for easy money.
2. The utilization of apprentices continuously on repetition work.

These conditions have been largely responsible for the present serious shortage of skilled engineers and no future scheme will have any better chance of success unless all interested parties are prepared to co-operate.

Whilst, in view of the widening scope of industry, it is not possible to visualise an omnibus scheme (nor would it seem desirable), the educational side should, as far as possible, be so arranged that acceptance will be accorded to schemes of a comprehensive nature, leaving the larger centres to elaborate these schemes by specialised courses for individual industries where the personnel involved will justify such courses. This would mean that the broad basis of the Ordinary National Certificates would be such as would allow a student to branch off for the Higher National Certificate in a variety of subjects.

On the practical training side apprentices should be under the control of some individual of reasonably high status who is independent of production and can counteract any tendency to make unfair use of apprentices or to confine their activities.

The apprenticeship scheme should be envisaged as a whole and not as a piece-meal effort, with varying conditions in different departments, and the course of training should be designed to give the apprentice as wide a view as possible of the complementary departments without prejudicing the training in his own sphere. It should also aim at giving facilities for advancement to more able men, even to the extent of allowing for the possibility of a university career.

The question as to whether or not a student should be allowed to attend day classes is a personal one but even the diehards are now coming to the view that evening classes are at the best only a makeshift as far as apprentices are concerned, although they can still serve a useful purpose in post-apprenticeship training for adults. In other words, evening classes should be confined to adult further education, and technical education current with apprenticeship should be given during the day time.

Opinions differ as to the most suitable form in which these courses should be arranged, but it is felt that the sandwich bi-weekly, monthly, or bi-annually, gives the student a far better chance of education and allows the works to absorb this labour with least amount of disorganisation, whereas absence on odd days in the week is bound to cause dislocation of production, which is one o the causes for interfering with production, and prevents the apprentice deriving the desired benefits from his practical training.

So far as engineering and allied trades are concerned a national scheme seems necessary to ensure that all apprentices shall reach a uniform minimum standard because the largest number of employers are small firms which cannot themselves be expected to make the necessary provision for such training.

It is considered that in the event of compulsory military training becoming established in this Country, the technical education of Production Engineers must be safeguarded during such training period or periods.

To summarize :—

1. Technical Education should aim at a common certificate in Engineering up to the Ordinary National Certificate standard, and should be based on broad lines so as to provide the necessary basis for subsequent specialisation. It should embrace the fundamentals of mechanics, materials and processes, and the use and manipulation of the simpler forms of machine tools.

The standard of mathematics up to this stage to be limited to the requirements of the student for the subjects he is studying.

From this point the student should have choice as to the line in which he desires to specialise, *i.e.*, electrical, mechanical or production, leading possibly to Higher National Certificates in these subjects, which should be assessed by the appropriate professional institution.

The more academic subjects are already well catered for and no comment is needed, but it is felt necessary to point out some at any rate of the appropriate subjects for students taking the Production Engineering Course.

Suggested advanced production engineering subjects are :—

Jig and Tool Design.	Press and Sheet Metal Work.
Metrology.	Welding Processes.
Metallurgy.	Hot Stamping and Forging.
Application of Electricity	Foundry Practice.
to Industrial Processes.	Time and Motion Study.
Machine Tool Design.	Industrial Administration.
Advanced Workshop Technique.	Production Control.
Plastics.	

The method of combining manual and technical training with the works is only attainable by very large firms, and generally speaking it is open to a serious objection in so far as it depends on the wax and wane of individual companies, which cannot be expected to train students in numbers exceeding their own requirements, and the training facilities, therefore, are liable to larger or smaller burdens within the normal capacity.

2. Apprenticeship schemes should be organised on the best possible lines with full collaboration from the Trade Unions and the Employers' Federation, and where factories are not large enough to envisage such a scheme, there should be joint arrangements with other smaller organisations.

3. Facilities should be available for students to take advantage of attaining the highest degree of education within their capabilities.

The Post War period is viewed with some concern as it is realised that this Nation depends almost entirely on its ability to compete successfully in the industrial field against other Nations.

This Institution is primarily interested in the Science and Practice of Production Engineering but also considers these subjects to be of extreme national importance.

Attention is drawn to the prominence given to Productton Engineering subjects by the Technical Colleges and Universities in the U.S.A and we in this country have much leeway to make up in this respect to ensure that industry plays its part in winning the Peace.

These subjects being of a practical nature, cannot be treated entirely on a theoretical basis, and any form of training whether at Universities or Technical Colleges, must necessarily be sandwiched with practical workshop experience.

Research Department : Production Engineering Abstracts

(Prepared by the Research Department.)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

HEAT TREATMENT.

Heat-Treating and Refrigerating Aluminium-Alloy Rivets. (*Machinery*, 13*th December*, 1945, *Vol.* 67, *No.* 1731, *p.* 657, 12 *figs.*)

The rivets are loaded into special baskets for easy handling in the electric furnace, the water quench, and the alcohol bath (which helps to dry the rivets and prevents them from freezing together in the refrigerator units). A large quantity of rivets is reclaimed from floor sweepings by machines which sort rivets according to diameter, type of head, and length.

Softening of Steel by the Isothermal Transformation of Austenite, by Frederick F. Dodson. (*Machine Shop Magazine*, *November*, 1945, *Vol.* 6, *No.* 11, *p.* 87, 3 *figs.*)

In austempering, the steel is quenched into a fixed temperature, usually between 250°-500°C. The structure is far superior to one that would result from orthodox oil quenching and tempering. With martempering, the steel is quenched into a medium at a temperature a few degrees Centigrade above the point at which martensite begins to form, usually around 210°C.

Each type of steel will need different temperatures whether austempering or martempering is to be carried out, and the use of "S" curves is necessary to obtain them. An example is described using S.11 nickel chrome steel. Times taken for treatment by usual method can be reduced 50 per cent.

High-frequency Induction Heating—A Comment, by E. Gregory. (*Machinery*, 29*th November*, 1945, *Vol.* 67, *No.* 1729, *p.* 608, 3 *figs.*)

A cluster gear was heat-treated by the Lepel spark-gap high-frequency machine, the heating time for four gears being 83 seconds. The tabulated figures of accuracy before and after heat-treatment show that a limit of 0.0006-inch has not been exceeded. Running tests were satisfactory. Subsequent vapour blasting gave a good finish, eliminating further operations. Costs are estimated.

COOLANT, LUBRICANT.

Selection of Lubricants by Formulae for Gear Units, by A. Booth. (*Power Transmission*, 15*th November*, 1945, *Vol.* 14, *No.* 166, *p.* 999, 1 *fig.*)

Energy, force, friction, heat, lubricants, viscosity, and surface tension are defined. The necessary requirements of a lubricant are : to separate the apparent contacting surfaces when under pressure and speed conditions, and to retain this property due to its viscosity and oiliness ; to reduce the frictional coefficient to a low value, and so generate the minimum of heat ; to have a high cohesive

property of attraction for the surfaces to form a tenacious oil film ; to be sufficiently mobile to ensure spreading to and wetting the adjacent substances, and to distribute the heat generated over a wide area ; and to have a high specific heat value, further to assist cooling by forming one of the connecting links from the point of heat generation to the atmosphere.

Common mineral, vegetable and animal oils are noted, and the properties of extreme pressure oils and greases are discussed in more detail. Particular attention is paid to gear lubrication. Selection of lubricant depends on type of gear, load and speed, size of unit dimensions, disposition of meshing zones in relation to oil sump, capacity of the oil sump, quantity of oil in circulation, space around the moving members, ambient temperature, and continuous or intermittent period of running. Bevels, spiral bevels, and hypoid gears, due to their particular tooth action and relatively high load capacity, demand an enhanced oil film strength, and extreme pressure lubricants are usually applied.

A chart has been evolved for the correct selection of oils, applicable to all types of enclosed industrial gear units. This chart takes into account all the factors previously mentioned, and is reproduced. Some lubrication difficulties and their solutions are indicated.

Oil Spray Collection on Thread-Grinding Machines. (*Engineering, 7th December*, 1945, *Vol.* 160, *No.* 4169, *p.* 477.)

A mist formed by oil particles and vapour pervaded the whole building, The solution was the fitting of a hood to each machine, suspended on tubular supports with its sides and back enclosing the wheel head, and its front having a vertical slot in the region of the wheel so that the whole operation was visible. The fumes were drawn out of the hood by a fan and passed through special impingement-type filters, the arrested oil from which was then drained back to the machine cutting-oil tank.

Coolant Improves Carbide Sawing of Steel and Aluminium Alloy Bars, by A. Leonhardt. (*The Machinist*, 15*th December*, 1945, *Vol.* 89, *No.* 36, *p.* 2060, 4 *figs.*)

Experimental set-ups indicate that high-speed sawing costs may be reduced to compare favourably with flame-cut and mill costs. Carbide-tipped saw blades $\frac{1}{16}$-in. wide were used with soluble oil coolant under pressure.

EMPLOYEES, APPRENTICES.

Shall We Go to the Country ? by M. I. Lipman. (*Industrial Welfare, November-December*, 1945, *Vol. XXVII, No.* 303, *p.* 180.)

Some problems associated with the establishment of factories in rural areas are reviewed. No project should be considered which requires more than 5 to 10 per cent. of skilled workers. The others must be engaged on such processes that the average employee can absorb sufficient skill to be able to pay his or her way as a producer in not more than four to six weeks.

In estimating the pool of labour available nothing beyond a five-mile radius should be included. The importation of skilled labour presents a special problem of social absorption into its new environment. Housing is apparently the major problem, but an even greater difficulty is to get happy relations between new and old inhabitants. Management grades are also lacking in the country, and must be imported ; their social absorption is even more of a problem, and they run the risk of technical and intellectual stagnation. Provided proper allowance is made in training, the country worker will give results which compare favourably with other centres, but is always slower.

There is sometimes a reluctance on the part of country workers to accept responsibility and promotion. A feature of rural industry is the one-factory

town, but this should be avoided wherever possible. Apart from being a potential "Jarrow" through reliance on one industry, there are social implications equally dangerous. The feudal monopoly of jobs by the Lord of the Manor may be exchanged for the potential despotism of a factory manager. Lack of competition between employers tends to reduce the standard of employment, and there is always the danger of the exercise of virtual monopoly of jobs being abused by junior management. Scandal and idle talk are features of industrial life in one-factory towns, and are a bad background for any organisation.

Our present system of local government in country areas is ill-suited to carrying the responsibilities of providing the necessary services. The recreational habits of town and country dwellers differ widely, and the absorption by a country area of a quota of town dwellers requires great care. The deficiencies of the present medical system in catering for the country dweller are more glaring than in the city. It is the human problems associated with rural industry which have not been tackled, and unless these are handled boldly, not only by managements but by the Government and by local authorities, then far from any further dispersal of industry, many undertakings which went to the country during the war will hasten back to the towns, leaving in their train unemployment and economic desolation.

Foremanship and Reconstruction, by F. J. Burns Morton. (*Machine Shop Magazine, November,* 1945, *Vol.* 6, *No.* 11, *p.* 60.)

The unit cost of labour can be reduced by (*a*) greater productivity from each person; and (*b*) greater utilisation of the efforts of each person. Positive, not negative, management is needed. Management must understand and work as a team with the foremen, who ultimately handle the men. The foreman must become a professional person with a code of ethics and a clear understanding of all the methods and manners of management that he must apply, and his status must be raised greatly.

One of the greatest difficulties is that the foreman himself has never been properly understood, since there exists no body to speak for him. There should be an Institute of Foremen with definite standards of knowledge and experience.

The Psychology of Workshop Management, by Harold W. Gee. (*Machine Shop Magazine, November,* 1945, *Vol.* 6, *No.* 11, *p.* 55.)

Controlling labour in peace-time is a vastly different matter from during the stress of war, and the successful peace-time manager must be imbued with characteristics which are useful but not so essential to success in war-time production, and the article is mainly intended for those with only war-time experience.

Joint Consultation, by W. B. D. Brown. (*Industrial Welfare, November-December,* 1945, *Vol. XXVII, No.* 303, *p.* 173.)

An account of the formal machinery for a company which comprises one parent factory, employing up to 2,000 people, and several dispersal factories, employing from 600 down to as few as 25 people. The success of this scheme was due to three features: (1) The calibre of those elected was very high indeed. (2) The provision of an intermediary works committee between the electorate and the joint works council eliminated many ill-advised proposals from employees. (3) The election of weekly paid members of the works and office staffs to the committee ensured a wider and better-informed outlook.

FOUNDRY, CASTING.

Die-Casting Close-Fit Threads, by R. E. McIntosh. (*Iron Age,* 30*th Zugust,* 1945, *Vol.* 156, *No.* 9, *pp.* 50–53, 96.)

Describes an automatic die-casting machine (the Kip caster) for Zn alloys

which gives rapid production on multicavity dies employing automatically unscrewed cores or dies to produce smooth cast threads.

(*Communicated by The British Non-Ferrous Metals Research Association.*)

JIGS AND FIXTURES.

Sprayed-Metal Jig Members in Aircraft Production. (*Machinery, 6th December,* 1945, *Vol.* 67, *No.* 1730, *p.* 625, 9 *figs.*)

The article describes in some detail the procedure adopted by the Lockheed Aircraft Corporation, in the production of certain jigs and fixtures by metal spraying on plaster forms. Zinc or Zinc Al. alloy is sprayed to a depth of at least ¼ inch, and a light coating of Al. or bronze is then added for strength. Reinforcement of the metal shell is sometimes necessary. Bushes, pins, etc., are initially placed in the plaster block and are held in the final job by the sprayed metal.

GEARING.

The Production of Precision Spiral Bevel Instrument Gears, by J. R. Westwood. (*Machinery*, 13*th December*, 1945, *Vol.* 67, *No.* 1731, *p.* 665, 8 *figs.*)

Control instrument gears for aircraft, military and naval requirements, although carrying practically no load, must function with the highest possible precision, and all angular movements must be accomplished to a very high degree of accuracy, largely dependent on concentricity, accuracy of pitch, and reduction of backlash. This article sets out, in detail, the methods adopted for curved-tooth bevel gears.

The various tolerances adopted for the machining of the blanks are given. To secure an accurate bore, broaching has been found to be very satisfactory. A taper plug gauge, easily and cheaply produced, gives accurate bore checking on through holes. To establish a datum face which is absolutely square with the bore, the most successful method was to secure the blank by a wring fit on a hardened and ground mandrel, machining at high speed with the blank driven by its bore fit. All succeeding machining operations were performed on mandrels which can be set to run true to within 0·0001 inch or less, on any machine. With sem-skilled female labour, very high speeds produced results of a high standard.

An attachment fitted to a Gleason No. 4 hand rolling testing machine is used for testing eccentricity, face angle, cone length relation to datum face, and back angle, in one setting by two dial indicators. The generation of the spiral teeth is performed on the 3-inch Gleason spiral bevel generator, by means of the duplex spread-blade method. The most conclusive test is the actual running of the pinion or gear, with its mate or an accurate master gear which may be selected from production, with the testing machine arbors placed accurately in position by set-up gauges.

Gear Tooth Curvature Treated Simply, by Ernest Wildhaber. (*The Machinist*, 15*th December*, 1945, *Vol.* 89, *No.* 36, *p.* 2064, 6 *figs.*).

A continuous use of the tooth normal facilitates determination of the curvature data which control the load capacity of tooth surfaces. The necessary theory is given in full.

MACHINING, MACHINE TOOLS.

Production Machining of Steel. (*Mechanical World*, 2*nd November*, 1945, *Vol.* 118, *No.* 3070, *p.* 485, 1 *fig.*)

Summary of some of the metallurgical factors affecting machining properties.

The importance of closely specifying and inspecting material to obtain consistent performance in conjunction with standardised tools is stressed. The effect of increasing the surface hardness of H.S.S. tools by nitriding and sub-zero treatments is mentioned.

Negative Rake Turning Tools Improve Roughing Cuts in Steel, by Carroll Edgar. (*The Machinist*, 24*th November*, 1945, *Vol.* 89, *No.* 33, *p.* 1151, 6 *figs.*)

For rough turning steel forgings, a carbide tool having a negative back rake of 5 degrees and a negative side rake of 5 degrees has been found satisfactory. The nose radius and reliefs should be as on a conventional tool. The tool should be set on, or slightly above, the centre line, with a side cutting edge angle of 10 to 30 degrees. Coolant is more often needed than when machining with positive rakes.

Speeds and Feeds for Cylindrical Grinding. (*Machinery*, 6*th December*, 1945, *Vol.* 67, *No.* 1730, *p.* 640.)

The article describes in general terms the combination of speeds and feeds for rough and finish grinding of cast iron and steel, together with the effects of depth of cut and in-feed. Eleven suggestions for overcoming common difficulties are given.

CHIPLESS MACHINING.

Design and Production Technique, by A. J. Schroeder, D.Sc. (*Aircraft Engineering*, *November*, 1945, *Vol. XVII*, *No.* 201, *p.* 331, 72 *figs.*)

Part IV. Principles involved in drawing. With the aid of many illustrations, the author gives very concise notes on: the process of drawing; ductility; ascertaining the area of surface of the blank and the diameter of the blank for shells and hollow bodies with any shaped surface and angular bodies with two axes of symmetry; comparison of cost, dependency of manufacturing costs on the number of pieces; drawing strain, selection of drawing tools, and the difficulties in the use of various primary forms.

MANUFACTURING METHODS.

Checking of Parts Requiring Compound Angles. (*Machinery*, 29*th November*, 1945, *Vol.* 67, *No.* 1729, *p.* 601, 9 *figs.*)

Difficulties encountered in producing compound angles are largely due to incomplete information being supplied on the working drawings and to lack of understanding by those who must produce and inspect the parts. A method based on a clear, understandable drawing, and a master part which is used for making a fixture, die, or jig to facilitate production, is described with the aid of examples. Shop requirements are considered throughout.

Motion Study Exhibition. (*Machine Shop Magazine*, *November*, 1945, *Vol.* 6, *No.* 11, *p.* 36, 16 *figs.*)

Advantages of the application of job analysis were demonstrated at the recent Motion Study Exhibition. A few of the demonstrations are reviewed briefly.

Motion Study, by James J. Gillespie. (*Industrial Welfare*, *November-December*, 1945, *Vol.* XXVII, *No.* 303, *p.* 183, 3 *figs.*)

Part 3: Motion Economy. Body motion is discussed in the principle of arm motion, principle of body use, principle of body posture, and principle of necessary changeover. Existing methods are strongly criticized, and the author

condemns the "simo" chart, and substitutes a motion record (M.R.) chart with no micromotion times and with dynamic symbols for major arm, leg and body movements.

The Manufacture of Fibreglass. (*Engineering, 9th November.* 1945, *Vol.* 160, *No.* 4165, *p.* 371, 6 *figs.*)

In manufacturing bat wool, numerous small streams of remelted glass are discharged from minute holes in platinum bushings into a transverse stream of high-pressure steam, and a cloud-like mass of filaments between 8 in. and 15 in. in length is blown into a receiving hood. It gravitates to a moving belt conveyor on to which it falls in a layer about 10 in. deep. Some felting takes place, but it is not suitable in this condition for such purposes as insulation. It is accordingly usually compressed to a degree appropriate to the particular form in which it is to be made up, this compression resulting in a range of weights from 3 lb. to 12 lb. per cubic foot.

The manufacture of continuous-filament Fibreglass is entirely different. Small spheres, each weighing about ¼-oz. are fed mechanically into a small electrically-heated furnace holding about 4 lb. of glass. The bottom of the furnace holds a platinum "bush" having 102 holes. These are drilled to 0.033 in. in diameter and reamered out to 0.037 in. in diameter. The molten glass is slightly cooled on leaving the platinum and is, therefore, in a viscous condition when it is drawn vertically in a filament 0.0002 in. in diameter. The collection of filaments is led over a pad which coats it with a special emulsion to prevent separation and passed round a rapidly-rotating vertical spindle, and then led on to a drum rotating at over 4,000 r.p.m. After twisting the thread is transferred to the warping machine which arranges the threads in parallel strands for the loom.

MATERIALS, MATERIAL TESTING.

German Cemented Carbide Industry, by Gregory Comstock. (*The Iron Age, 30th August,* 1945.)

A lengthy article dealing with an investigation, that was instituted in March, 1945, into the German hard cemented carbide industry. The industry was accorded high priority by the German authorities, and plants were removed repeatedly from bombed and other endangered areas. Krupps received 84 per cent. of the raw materials used for cemented carbides. The industry was eventually rationalised as regards shape, quality, etc., of product, and finally there was complete central control of production. The total production rose from 81,964 kg. in 1938/39 to 509,186 kg. in 1943/44.

The article quotes capacities of the various plants and tabulates compositions and physical properties of the standard German carbides. There was a swing over to the use of columbium. The recommended uses of the various grades of carbide are listed, and methods of manufacture are described.

(*Communicated by Machine Shop Magazine.*)

Special-Purpose Bronzes, by J. A. Oates. (*Aircraft Production, December,* 1945, *Vol.* VII, *No.* 86, *p.* 595, 16 *figs.*)

The author gives a thorough description of the control exercised by Langley Alloys, Ltd., in the production of numerous types of special purpose bronze. Both the laboratory techniques and the functions of the technical works control department, in each type of process (melting, sand casting, forging, rolling, etc.) are considered.

MEASURING METHODS, INSPECTION.

Detection of Deep Flaws in Metals by Supersonic Wave, by D. O. Sproule. (*The Machinist*, *8th December*, 1945, *Vol.* 89, *No.* 35, *p.* 2013, 7 *figs.*)

The use of supersonic waves for non-destructive testing of materials has now been developed for practical purposes, and introduced into engineering practice. It is claimed that a $\frac{1}{32}$-in. diameter hole 4 feet below the explored surface has been easily detected. Detectors have been applied to the testing of aluminium used for the extruded spars of bomber aircraft; the testing of armour-plating of shells and bombs, for hair-line cracks; the examination of railway wheels and precision gear blanks; and high-speed steel for tool-making.

The principles, construction, and use of a detector are described.

PLASTICS, POWDER METALLURGY.

Moulding Presses for Plastics. (*Machinery*, 13*th December*, 1945, *Vol.* 67, *No.* 1731, *p.* 669, 3 *figs.*)

A review of the principal types, capacities, and general design features of presses for moulding plastic materials.

Processing Techniques Affect Design of Powder-Metal Parts, by P. Schwarzkopf and A. Reis. (*The Machinist*, 1*st December*, 1945, *Vol.* 89, *No.* 34, *p.* 1184, 6 *figs.*)

The suitability of design for manufacture from powdered metal are discussed in relation to tooling and material suitability.

RESEARCH.

Milling Cast Iron with Carbides, by Michael Field and W. E. Bullock. (*Mechanical Engineering* (*U.S.A.*), *October*, 1945, *Vol.* 67, *No.* 10, *p.* 647.)

The paper presents some of the data obtained in a research at the University of Cincinnati, done in co-operation with the Cincinnati Milling Machine Company.

The primary object was the quantitative investigation of those factors which basically determine the milling of cast iron. Three grades of Meehanite (B.H.N. 190, 220, 230), and single-tooth cutters were employed on a 25 h.p. miller. Cutting speeds ranged from 200 to 1575 f.p.m. and feeds from 0.005 to 0.065 in. per tooth. Tool life determined from the width of wear on the clearance land, surface finish, the formation of burr at the workpiece edge, and power were observed. Curves of cutting speed against total volume of metal removed for various feeds show a maximum tool life towards the low speed range; the harder the cast iron, the lower the speed. It is claimed that the machinability of cast irons, for a given cutter, can be compared only by the curves relative to tool life.

Carbide Milling of Steel, by A. W. Meyer and F. R. Archibald. (*Mechanical Engineering* (*U.S.A.*). *October*, 1945, *Vol.* 67, *No.* 10, *p.* 659.)

This is an account of milling tests on three steels representative of soft, medium, hard and extremely hard steel. The most satisfactory angles, feeds, and speeds are given.

SHOP ADMINISTRATION AND MANAGEMENT.

Machine and Labour Utilisation, by Wm. F. Walker. (*Mechanical World, 23rd November,* 1945, *Vol.* 118, *No.* 3073, *p.* 569, 5 *figs.*)

The means by which the maximum use of machines and labour are co-ordinated in the production plan is of the utmost importance in the economical running of any factory. Machines are bought, serviced and equipped, and labour is engaged and trained for the main purpose of producing. If either of these producing agents is idle then the potential producing or earning capacity of the factory is reduced. The basis of the system described is an inventory of all machines, equipment, and labour, expressed in a total of available hours. This total must be balanced against the required hours as planned, the necessary adjustments being made by sub-contracting or altering operational layouts. The steps in this process are explained in detail.

Production Planning, by D. Tiranti. (*Aircraft Production, December,* 1945, *Vol. VII, No.* 86, *p.* 592.)

The author gives a long survey of various writers' definitions of the different divisions of the field. His definition is : Production planning shall be that division of an industrial concern which shall be responsible for preparing all the necessary manufacturing data in order that the finished product shall be made in accordance with the stipulated requirements.

SURFACE, SURFACE TREATMENT.

Designing Porcelain Enamelled Components. (*Machinery Lloyd, 24th November,* 1945, *Vol. XVII, No.* 24, *p.* 86, 5 *figs.*)

The base material should have a low carbon content, a good surface texture and freedom from impurities. The building up of several parts welded together to form a complete unit before enamelling has a number of advantages and disadvantages, and these are enumerated. General principles are : Sharp corners should be avoided. Edges should be strengthened by flanging and large areas by embossing, whilst long, straight edges should be reinforced and flanged joints should be welded where possible and corners strengthened by the use of gusset plates. Cut-outs should be reinforced by flanging or embossing. Welded attachments should be avoided and parts should not be welded together so as to restrict the uniform expansion and contraction of large areas. It is good practice to distribute the metal throughout the structure as evenly as possible. Hanger supports should be designed so that they distribute the load evenly.

Manufacturing precautions include cleanliness, sharp and square shear blades, punches and dies. The basic considerations for forming are to prevent the internal strains in the metal that may be set up by failure and to regulate the movement of the displaced material properly : suitable designs to avoid warping are indicated.

Corrosion Protection, by T. S. Bugg. (*Mechanical World, 2nd November,* 1945, *Vol.* 118, *No.* 3070, *p.* 493, 4 *figs.*)

Collected information on present-day processes and methods.

WELDING, ETC.

Gas-Cutting of Stainless Steel Aided by Fluxing System. (*Iron Age, 9th August,* 1945, *Vol.* 156, *p.* 61.)

The oxides of the metals which confer on stainless steels their unique qualities are of such a character that when the steels are oxygen-cut the slag produced is

viscous, and tends to create a refractory layer, which prevents the heat and the cutting-gas from penetrating to fresh layers of metal.

The problem thus presented has been solved by the incorporation, in the gas-stream, of a fluxing material which reacts with the oxides of nickel and chromium, forming fluid slags which are more readily washed out. Apart from the addition of the fluxing apparatus, and slight modification in the oxygen-control, standard gas-cutting equipment is used. It is claimed that by the new process it is possible to cut a 1-inch plate of 18-8-molybdenum at the rate of 8–9 in. per minute and that a 2½-in. slab of 25–12 stainless steel can be cut at a rate of 3½ in. per minute, leaving a relatively smooth-faced kerf. It is anticipated that the process will be applicable for the rough-cutting of stainless steels of considerably heavier section.

(*Communicated by The Nickel Bulletin.*)

Agricultural Machinery, by C. G. Bainbridge. (*Welding, December,* 1945, *Vol. XIII, No.* 11, *p.* 516, 6 *figs.*)

The author describes the production of welded farm equipment and the methods employed. Some details are given of the welding department of a firm specialising in agricultural machinery. Output has been greatly increased by the adoption of welded designs.

Magnesium Alloy Sheet and Tube, by E. Ryalls. (*Welding, December,* 1945, *Vol. XIII, No.* 11, *p.* 499, 21 *figs.*)

The weldability of magnesium alloys, weld design, joint preparation and welding technique are discussed from a practical viewpoint. Examples are included of this type of fabrication, with special reference to the aircraft industry, and the best methods of overcoming various problems explained in detail.

Welding Chromium-Nickel Steels. (*Welding, December,* 1945, *Vol. XIII, No.* 11, *p.* 520.)

Part I. Details are given of the metallurgical factors involved in the welding of chromium-nickel steels. Columbium- and titanium-stabilised types are also considered and a review of the desirable welding rod compositions is given.

Flash and Butt Welding Light-Gauge Ferrous and Non-Ferrous Metals, by T. Watson and A. J. Hipperson. (*Welding, June,* 1945, *Vol.* 13, *No.* 5, *p.* 188–197.)

The authors determined the conditions giving satisfactory flash-butt welds in light-gauge steel (0·028 in. thick), but found that the conditions were much more critical for welding 60/40 brass of the same gauge. Factors involved were investigated and re-design of the machine to give satisfactory welds in brass is described. Final process represents a combination of butt and flash-butt welding.

(*Communicated by The British Non-Ferrous Metals Research Association.*)

The Spot Welding of Heavy Gauge Aluminium Coated Duralumin, by H. E. Dixon. (*Welding, December,* 1945, *Vol. XIII, No.* 11, *p.* 486, 7 *figs.*)

Heavy gauge light alloy sheets present particular spot welding problems. The author discusses results obtained from British and American equipment. Data relating to weld quality as affected by various factors is given and also recommendations for suitable welding technique based upon recent investigations in this country. Factors described include: general supply and machine problems, equipment used for heavy gauge welding, weld quality (shear strength, consistency, porosity and cracking), current shunt losses, effect of weld spacing and specimen size on strength and consistency, and welding technique.

Quality, Control and Spot Welding, by N. G. Dod. (*Aircraft Production, December,* 1945, *Vol.* VII, *No.* 86, *p.* 563, 2 *figs.*)

The method of controlling the shear strength of spot welds in Al shear is simply explained from the initial installation stages to routine work. Norma

inspection routine is still necessary for bad location, indentation, irregular shape, etc., to which numerical analysis cannot be applied.

WELFARE, SAFETY.

The Fencing of Dangerous Parts of Machinery, by H. A. Hepburn. (*Machinery, 6th December*, 1945, *Vol.* 67, *No.* 1730, *p.* 631, 9 *figs.*)

The design and use of automatic and interlocking types of guards for press, milling machines, etc., are described and mention is made of various types of telescopic guards for drilling machine spindles.

WORKS AND PLANT.

Income Tax in Relation to Industrial Buildings, Plant and Machinery, by L. Bennett. (*Mechanical World*, 23*rd November*, *Vol.* 118, *No.* 3073, *p.* 575, 10 *figs.*)

The writer explains the various allowances to be given under the 1945 Act and illustrates a practical method which would be required to obtain and control the yearly figures.

Three-Dimensional Plant Layout With Scale Model Equipment, by Charles Fyfe. (*Machine Shop Magazine, November*, 1945, *Vol.* 6, *No.* 11, *p.* 47, 3 *figs.*)

Three-dimensional planning makes planning more accurate, introduces the third dimension and gives perspective, assists in the assessment of utilisation, visually aids in determining storage areas, and makes the whole company conscious of the value of factory facilities. The implications of these features are amplified and analysed.

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

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Murad Machine Tool Co., Ltd.	vi A
Murray Colour Controls, Ltd.	xxx B
Newall, A. P., & Co., Ltd.	xxxii A
Newall Engineering Co., Ltd.	xvi B
Newman Industries Ltd.	xxviii A
Parkinson, J., & Son	iv B
Pryor, Edward, & Son, Ltd.	xxiv B
Ransomes, Sims & Jefferies, Ltd.	xxvii B
Reavell & Co., Ltd.	xiii A
Sanbra, Ltd.	xii A
Sanderson Bros. & Newbould, Ltd.	xxviii A
Selson Machine Tool Co., Ltd.	ii A
Snow & Co., Ltd.	xxv B
Taylor, Taylor & Hobson, Ltd.	ix A
Timbrell & Wright Machine Tool & Engineering Co., Ltd.	xxix B
Urquhart, Lindsay & Robertson (Orchar), Ltd.	xix A
Ward, H. W., & Co., Ltd.	v B
Ward, Thos. W., Ltd.	xxvi B
Wickman, A. C., Ltd.	ii B vii A
Wolverhampton Die Casting Co., Ltd.	ix B
Woodhouse & Mitchell, Ltd.	xxii A

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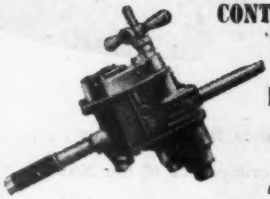

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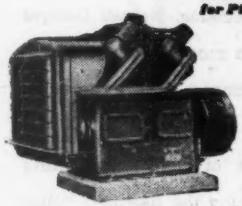

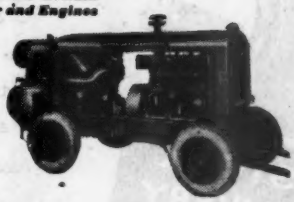

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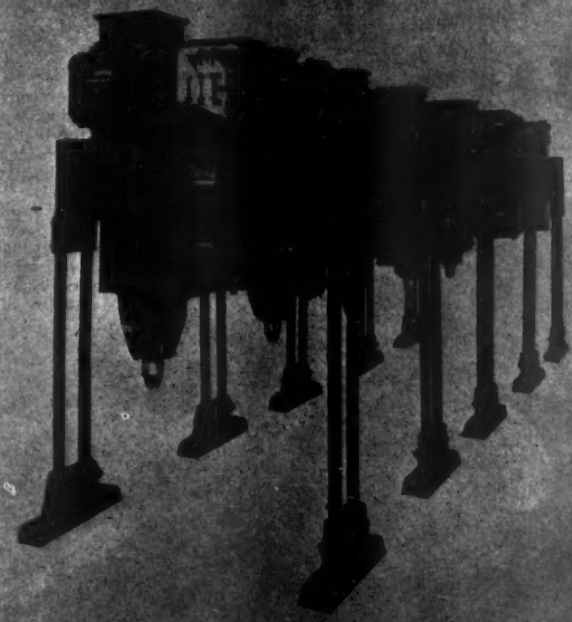

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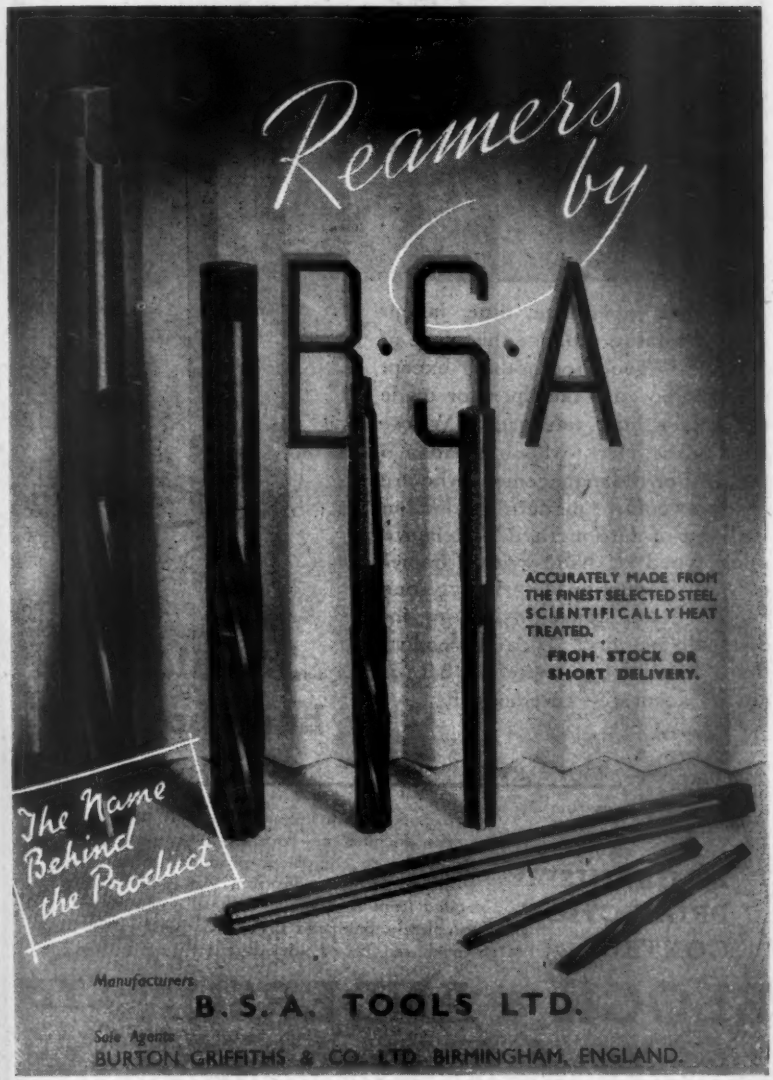
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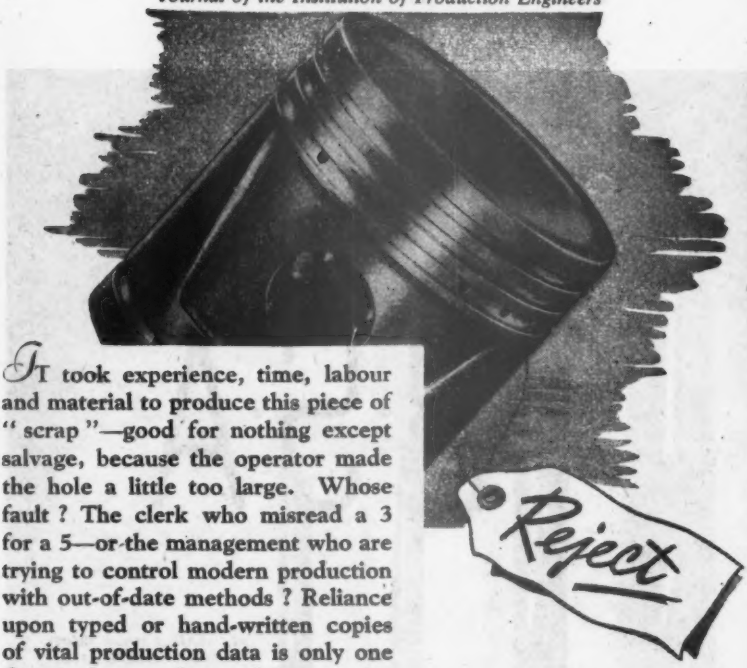

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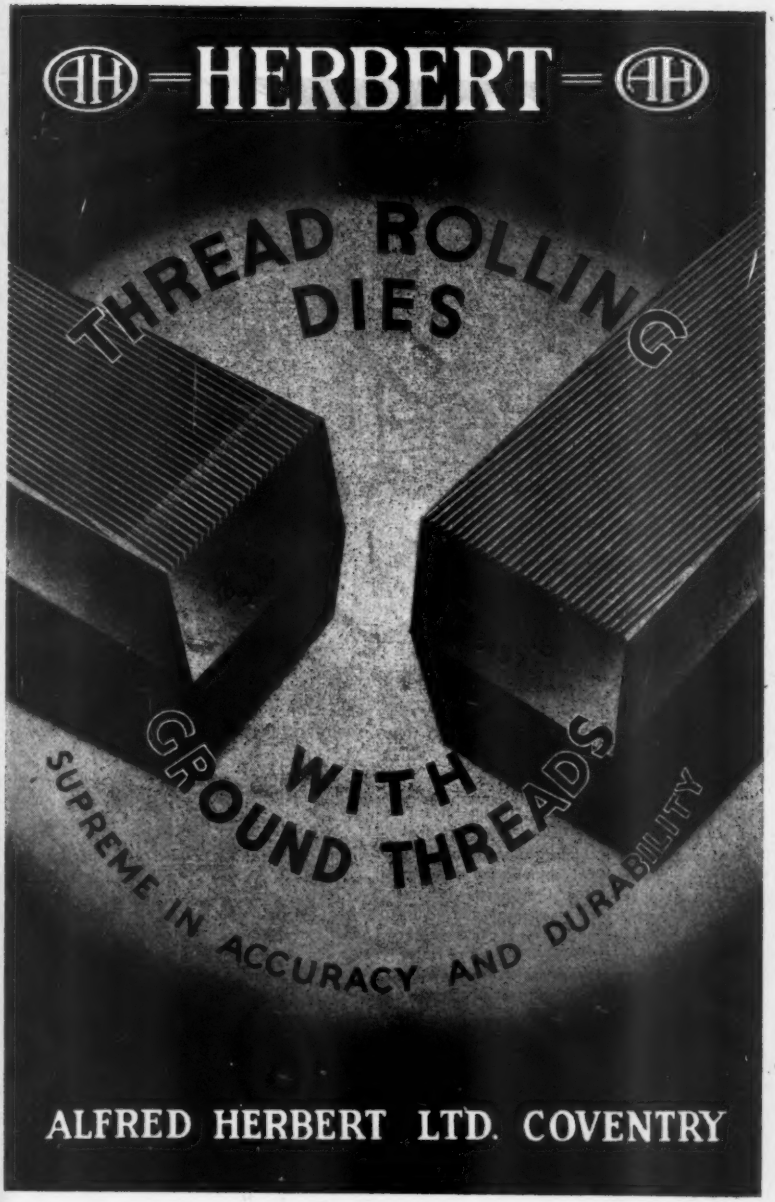
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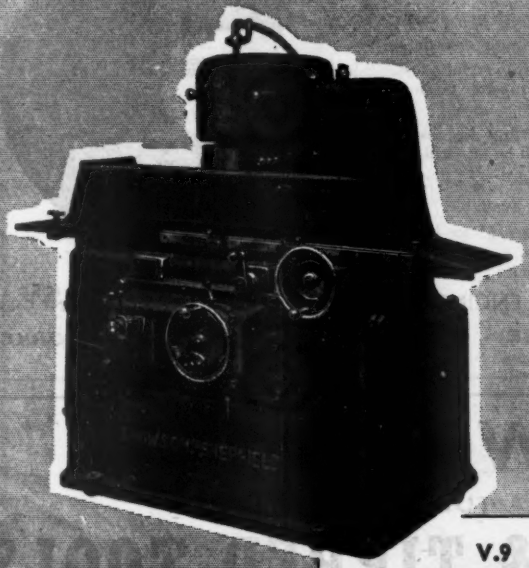

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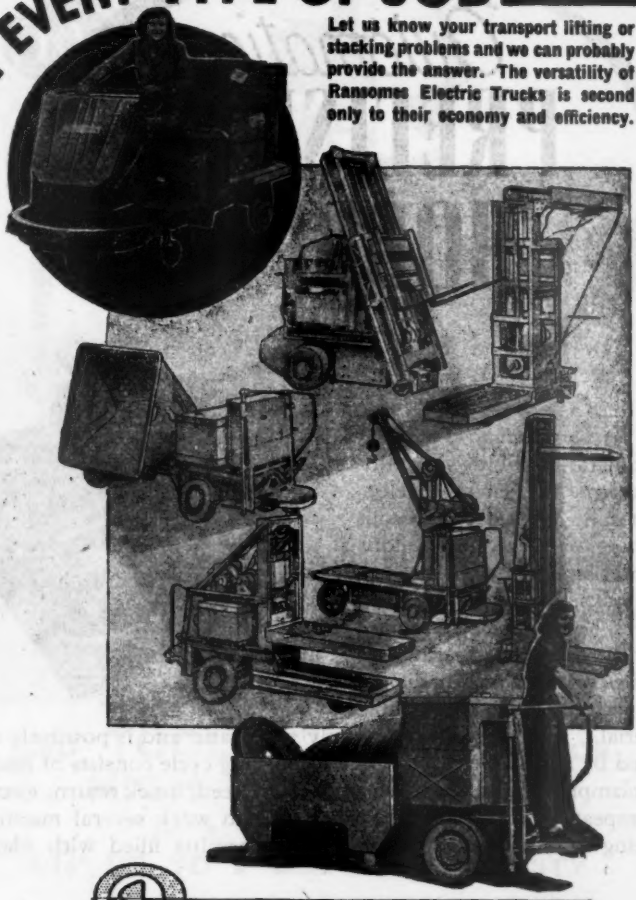

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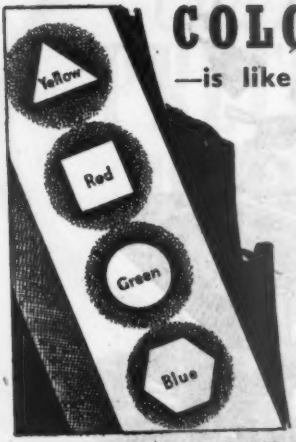

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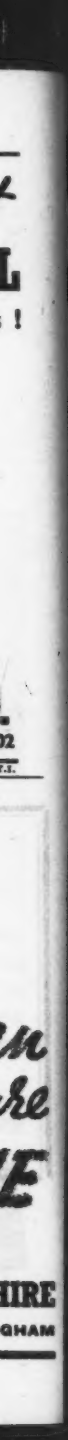

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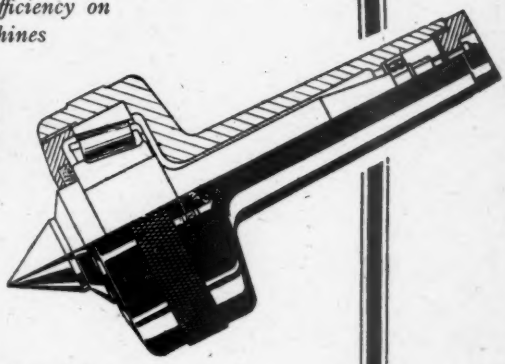

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